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ABSTRACT

From a series of lectures, a selection of eight are oriented principally toward the biologically developing child, and the physiological operations in visual process. The numbered lectures are--(1) The Coordinated Classroom, its Philosophy and Principles, (2) An Outline of a Biological Point of View, (3) The Evolution of Structure--despite man's adaptability, he can not ignore nature's laws, (4) Some Principles of Growth and Development--material presented for the purpose of providing reader and author with a common starting point for discussing some phenomena occurring in children engaged in visually centered activities of the classroom, (5) A Dynamic Point of View, Part One--the organism constantly tries to shape itself and its internal balances to the forces in its particular surroundings to reduce the stress of those forces, (11) An Outline of Vision and Seeing, (12) Vision, Growth and Development, (13) Vision as a Dynamic Process, Part One, and (15) Vision and Lighting, Part One--promoting efficient vision requires a concern for more than quantities of light and distribution. Also included is 'An Outline for Further Study' abstracted from the series "Vision, Growth, and Development", January 1949, by D.B. Harmon. Related bibliographic material is cited throughout the work. (KK)

CO-ORDINATED CLASSROOM LECTURES

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Lecture 1

THE CO-ORDINATED CLASSROOM[1]

Its Philosophy and Principles

If we accept the concept, as most educators do, that the child operates as a totality--that organically he strives to grow, develop, and function as an integrated whole inseparable from the environment in which he finds himself--then we must recognize there are, in effect, at least two teachers in every classroom. One is the human teacher who plans and implements the child's educational experiences. Present also is a combination of physical forces and forms that set into action the child's basic biologic behaviors from which he derives social and personal learnings from those educational experiences. Each of these teachers is of equal importance to the child's development.

Our multi-faceted unit, the child, as a physical organism shares with all other organisms the fundamental need of coming to terms with his physical surround in order to survive. His unique capacities as a human being make it possible for him to derive new experience from past experience; to project experience into the future through thought and imagination in planning later actions; to manipulate symbols experientially; and, to communicate through symbols. Nevertheless, whatever these unique capacities may promise for his social and psychological efficiency, biologically they merely facilitate, through experience, the child's basic functions of coming to terms with physical forces and things. They do not excuse him from meeting fundamental survival needs, nor do they provide substitute ways for meeting them outside the physiological mechanisms inherent in the child's physical structures. For wholesome and optimum total development, the satisfaction of organic need must precede or be inherent in both the continuing processes of acculturation and in each immediate process concerned with meeting a social or psychological demand.

In each learning task the child must first be free to find balances with gravity, through minimum effort, before he can learn his orientation with, and the localization of, that task. Through time, he also must find continuing satisfying ways of meeting gravitational demands before he can finally achieve optimum orientation in his natural and social worlds, and localize in those worlds meaningful forms and things. His physical responses to gravitational forces are the behaviors from which he derives his orientation to his space world.

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[1] Published in part, Nation's Schools, March 1949

Before he can define an environment filled with useful experiences, the child must adjust biologically, again with least effort, to each of the immediate forces in his surround. These forces are represented in the total distribution patterns of light, sound, heat, and similar energies. His dynamic physical adjustments to physical forces are the foundation actions by which the child learns to "see", "hear", and "feel" in a psychological and social sense. The successful and efficient achievement of these foundation actions are inseparable parts of the child's mastery of the symbols of experience represented by spoken and printed words.

The child must find satisfactory physical relationships between the bodily demands of stimulating forces in his external physical world and his visceral requirements at any time, before he can derive acceptable attitudes and values from his educational experiences. It is from the nature of the biological stresses set up in him by constantly changing external-internal demands on the child's limited physiological resources that the organic child evaluates whether overt actions are biologically worth while. To operate within its resources the organism must constantly equate the demands for energy and mechanisms for bodily performances towards its external world, and the needs for visceral function to maintain biological integrity. These demands and needs are often in conflict in a social or artificial world. These continuing external-internal adjustments and biological evaluations are the behaviors basic to building the child's attitudes towards experiences within his learned, or cultural worlds.

Both moment-to-moment and continuing physical adjustments are made to the shifting gradients of physical forces, represented by the distribution of light, sound, temperature, required movements, physical restraints, and the like, existing in any surround. Together with the attitudinal changes represented in the constantly altering physiological gradients of all aspects of internal metabolic processes, these adjustments are the major part of what is meant when we state in educational psychology that learning is derived from basic biological behaviors. These behaviors are capable of direction into socially and personally useful performances providing we do not defeat the satisfaction of essential biological needs.

These essential needs are the completion or maintenance of all the required external and internal physical adjustments with least effort while the educational task is being performed. Optimum growth and positive development are the products of simultaneously maintaining these various adjustments to physical forces while continuing the physiological performances of educational tasks, and doing both efficiently. This means that combined demands for both the physiological mechanisms of performance--eyes, hands, trunks, nerves, supporting bones--and energies of operation must be well within the child's free resources of each at any time. The biological processes of coming to terms with the physical factors of the surround, and the processes of acquiring cultural tools and skills must each reinforce the other, without either encroaching on the other's organic purposes or needs.

In simple English, all of this means that the physical surround in any learning situation is not merely a shelter or enclosure. It is the prime producer of the actions which educators modify to produce essential learnings.

Classrooms and schools have far too long been planned in terms of the social ends sought, rather than in terms of the processes entering into attaining those ends. The total organism and all its needs and actions in any learning situation has too often been neglected in classroom planning. When a physical factor such as light has been taken into account in planning, only those aspects of light of apparent and immediate visual relationship to the eye-mechanics of resolving the visual task, have been considered, rather than all the lighting factors related to the visual processes which make the successful performance of the visual task possible. Similar approaches have been made to sound and temperature control, ventilation, equipment design, and the like.

Classroom design has been planned largely as if learning automatically resulted from exposure to social symbols and forms, with the child shutting off his adjustments to forces and forms not entering immediately into the outline of experiences prescribed by the course of study. Education's catch-phrase, "the child learns through activity", seems to have been considered merely as describing the most readily determined overt motions demanded by instructional materials. All other behaviors have apparently been attributed to problems of "capacity", "aptitude", "discipline", or even "delinquency".

Researchers and thinkers in the field of child development, from Dewey to Olson and Gesell, have shown us that the processes of growth and development are orderly and predictable. They have shown us, in addition, that the processes of growth provide the child with combinations of mechanisms at various steps in his developmental sequence which make for certain kinds of generalized behavior towards physical factors in the surround.

These generalized behaviors operate whenever the physical factors which set them into action exist as adequate stimuli in a surround, or, whenever internal need (such as visceral stress or hunger) sets the organism into action to seek those factors. Researchers in the learning process have shown that these definable generalized behaviors can be both refined and directed toward specific forms and goals, provided their new specific operation and direction still satisfy biological need (which merely means that they still satisfy the biochemical and biomechanical functions and limits inherent in the physiological systems producing those behaviors).

Anatomical and physiological workers (such as those ranging from Hemholtz to Duke-Elder on the structure and operation of the eye) over many years have been giving us meticulous descriptions of the structure and immediate physical operations of various limited parts of the body, until we now have detailed descriptions of virtually every part of the human body, including the limits of physical function of those parts. In turn, researchers in experimental psychology and psychophysics (such as Lashley, Halstead, Renshaw, Nafe, and a multitude of others) have been showing how the operations of these various parts are converted into higher functions. They also have been defining the limits of both these operations and functions.

Innumerable psychologists, sociologists, and philosophers have laid before us the ranges of personal and social behavior and the limits and goals of group living; educationists have interpreted these into programs of desired experiences and training. Why then, with all this mounting information, have school plant design and the processes of learning and development remained so far apart, especially in the face of various enumerations of pathologies or difficulties in school children which can be statistically attributed to factors in the school plant, such as improper lighting and school seating? Two answers may indicate the reasons.

The first of these is probably that we have lacked efficient ways of integrating into educative processes and planning the findings of other fields concerned with children, and with human development and function. The second lies in the limitations of educational resources--finances, plant, personnel, and broad research. These have all contributed to restricting our thinking in developing educational method in a manner that forces the whole child out of our consideration, even though we recognize his place in the educative process through lip-service and generalization. Educational methods have been concerned largely with implementing our newer recognition of the immediate factors entering into the development of emotions and higher psychological functions, and with implementing social goals. These implementations have been principally derived from ends and not the processes of attaining those ends. Our preoccupation in defining educational experiences has been with the selection and organization of social tools. Physiological concern in educational method, when it has been considered, has dealt principally with the child's organs immediately involved with the manipulation of the social tools furnished him, rather than with total biological function and concomitant psychophysical processes, and ways of directing the various expressions of these into specific personally and socially useful forms.

In these preoccupations we have unconsciously made a number of erroneous assumptions concerning the processes of learning and development, including those pointed out earlier. Most of these lie in failure to recognize the biological purposes of the organism. Concern with only the anatomical parts of the child seemingly used in handling the tools of the course of study gives us no more insight into the physiological processes going on in the child that must be directed for constructive educational experience, than do piece-meal samples of his psychology. In physiology the statement that "the whole is different than the sum of its parts" is just as true as it is in psychology.

Because recent studies are showing that vision is probably the dominant function in development and learning, an elaboration of the above within the field of vision might be in order. Our selection and construction of instructional materials to be handled visually by the child have been made largely in terms of that part of the optics of the human eye (central field optics) apparently related to resolving the details of the task materials (letters, words, forms, objects, etc.). Classroom lighting, if planned at all, has largely been planned from this same limited instructional and optical view-point. The physiological optics implied in the anatomy of the eye, a concern of the ophthalmologist, is considerably different from the total processes of vision, and learning through vision, with which the educator has to be concerned. While the school must be concerned as to whether the child has a healthy eye, and whether the classroom light is adequate for central-field resolution, mere concern with the efficient optical operation of the eye and sufficient light on the task are far from enough. Glare-free task lighting and good eyes do not automatically convert the optical stimulus into meaningful objects, surroundings, or printed symbols. These take form and meaning only through the experiences of the organism, which include not only the perception of the central field details, but also the total actions elicited, concomitant posture and postural changes, associated sensory-motor experiences through other modalities, and, responses to the total light pattern in the entire visual field. Studies in visual dynamics made by some of the experimental psychologists previously mentioned, and by many others such as Marshall, Talbot, Bartley, Kohler, Wallach, and the more recent one in developmental optics by Gesell and his associates, all sum up to show that vision as related to learning is much more than the central optics of the eye. For the purposes of the school, vision is all the light-related actions of the child, plus the child's freedom in the classroom to carry through those actions efficiently.

Our knowledge, both old and new, of different anatomical systems and their biological processes apparently related to learning has all tended to confirm that "the child learns through activity", by showing that action or movement is an essential part of the function of these systems in adapting the organism to an environment. However, when we have set about in the past relating various physiological and psycho-physical findings to educational method with the physical tools then at our disposal in order to determine action patterns significant to learning, we have found our results falling far short of usefulness.

Investigative procedures drawn from older biology, mechanics, statistics, and thermodynamics of closed systems, and applied to existing morphological data on various body systems and growth processes gave us very unsatisfactory results in understanding the action bases of learning and in translating biological actions into educational method. These results have been so unsatisfactory at times, that some educational psychologists were led to say, "there is no place in psychology for physiology ". About the only thing derived from most of these studies were qualitative observations of some of the overt actions of a few of the body systems immediately related to the manipulation of instructional materials. In other words, such physiology as has entered into educational planning has related only to a limited number of peripheral parts of the organic child, and not to the integrated actions of the whole organism which, in last analysis, determines the use made of those parts and the generalized behaviors convertible into learning. Unfortunately this limited physiology used in education has influenced classroom planning to the detriment of both the organic child and the objectives of the school.

Recent works in biology, mathematics, and physics are showing us, both directly and by analogy, that our past difficulties in defining fundamental biological actions related to learning have not been due to deficiencies in our basic hypotheses. They have been products of the limitations of the physical tools we have used in our efforts to determine the total processes of the child that must be directed in acculturation. Contributions in biochemistry, biophysics, neurology, statistical mechanics, thermodynamics of open systems, operational physics, mathematics of communication, and the use of the dimension of time in studying biological phenomena, by such workers as Shannon, McCulloch, Von Bertalanffy, and Weiner (to name only a few by way of illustration), are demonstrating the shortcomings of our older physical tools for appraising biological purpose and function, and are also furnishing us with new methods leading to a better understanding of total organic action.

These newer tools, when applied to an analysis of existing data from all the fields mentioned earlier, begin to resolve the significant but apparent conflicts among the various data from different specializations--conflicts that have made sterile our efforts in the past to apply separate findings regarding biological action to the development of educational method and structure. These conflicts in data, we find, have not been due to some immeasurable process in the child, or to some inherent dualism in his makeup, but have been the product of the inadequacies of the older statistics, physics, and biologies from which we have derived our physical instruments for analyzing our data. With the application of these newer tools we begin to see emerging useful, quantitative concepts applicable to the utilization of biological actions of the total organism to both the direction of effective acculturation of the child, and to defining classroom structure.

For our purposes here, a few of these newer derived concepts of basic biological action are necessary. The basis of biological survival is action. The basis of learning is also action. Survival actions are directed towards changing the relationships of the organism with the physical energies and limits of any environment, and towards adjusting internal activity both in parts and between systems: all towards a steady state (a kind of dynamic equilibrium or balance). The maintenance of integrity of the total organism directs all of these actions towards attaining or approximating their ends with least effort and with least function. These actions are concerned with adjusting body mass with gravity, body centering with gradients of light and sound, anabolism with catabolism, and the like, to meet all the physical demands of organic continuance within the resources of the organism.

Learning actions, from the viewpoint of the school, are discrete actions within and beyond the mass actions of certain systems of the body concerned with survival activity within as well as outside of the physical classroom. Learning actions are directed towards changing relations with or manipulating selected or designated parts of the energy organizations, limits, or objects within the environment. Some of these actions are discrete changes within the internal economy of the organism, in addition to discrete actions directed into space. All these learning actions are possible because of certain latitudes, tolerances, or reserves within the mass survival mechanisms and actions from which they are derived; but, they are not separable from them. To illustrate: a child cannot hold and read a book independent of his adjustments to gravity and the total light in his visual field; nor can he listen to the words of a teacher outside his basic actions of adjusting to gravity and sound. The movements of writing and drawing are not possible outside of the actions of coming to terms with gravity, with light, with the placement of the working materials, and with the equilibrating adjustments to the movements of performing the task itself.

All action modifies the organism to fit the physical factors of the specific surrounds in which the action takes place, whether the actions are those of basic survival or those of directed learning. These actions in turn modify subsequent actions. Because learning action is within the mass action of survival, a modification induced in one type of action modifies both types of actions. Because learning action involves a complex of actions in relation to different energy forms and physical limits, a modification in the action towards one of these energy forms or physical limits, modifies or delimits the related actions towards all the associated energies and limits. For these reasons the physical limits and energies of the school plant and classroom are inseparable from the actions involved in responding to the course of study.

Definition of architectural function for the classroom and the school must start with the biological actions to the task surround from which the task actions are to be derived; then include the effective physiology of the specific tasks to be performed, and the growth and developmental status of the children who will perform the tasks; and, take final shape from the psychological and social aspects and implications of the tasks and task materials. Omission of any of these steps deviates, or defeats, the purposes of the school.

What are the essential aspects of these actions which the school designer must take into account? First of all, the actions with which we are concerned here are both overt and covert movement, not only through space but also through time. The movements with which we are concerned are directed by both organism and culture towards certain biological, psychological, and social goals. Directed movements call for frames of reference (coordinates) and for limits.

The frames of reference for the organism's movements through time are derived from the steady state the organism is attempting to maintain, in which every internal and external action, and actions between them, would be balanced by equal counteractions, and the entire process would be carried on with least effort and least mechanism. Stimulation upsets the balances of some system, or systems, of the body, and the actions brought forth are directed towards restoring those balances (the "tension: tension-reduction" formula of positive learning). Because learning actions are within the same mechanisms as those for basic biological actions towards maintaining balances with the forces and limits of the surround, the organization of illumination, sound control, heating, ventilation, seating equipment, and the like, must be such that the organic action necessary to maintain the organism's balances with them tends towards least action, in order that there will be maximum of freedom and a maximum of resources available for purposeful learning actions. In addition, the gradients of distribution of each of the energies throughout the physical surroundings must be such that any segment of them making an effective field at any time (such as the total visual field around any task) will have resultants centering with the task to be performed. In this manner coincident vectors of stimulation are provided for both body balance and for task performance. Only with this type of planning is it possible to have equally effective performance from a child in various group or activity centers throughout the room, and equally effective educational results from his performance from one location in the room as the center of his task or attention is shifted through various positions in the room. As the writer has pointed out elsewhere (THE CO-ORDINATED CLASSROOM, 1949) in the case of lighting for example, the only distribution pattern that will satisfy all these needs of the child would be one that would provide a comparatively even three-dimensional distribution of the light in all of the visually purposeful areas of the classroom--a "light solid" in other words.

The frames of reference for movements through space, equally essential with those for movements through time, in determining classroom design, are found in the coordinates of the child's body itself.

Various vertical and horizontal planes of the body of the standing or seated child (free of restraint and held in balance with gravity with least effort, and not performing a purposeful task, but at optimum readiness to move or perform) describe a standard three-dimensional system of coordinates, or frame of reference, for his actions. His movements in changing his relationships with areas in space, and his movements in the performance of tasks, arise and are directed as momentary shifts of relationship of the planes determining these coordinates (coordinate transformations), or as functions on the system of coordinates determined by these planes. His learnings and knowledge of the organization and contents of his space world grow from his projections of these coordinates of his body and body mechanisms out into space as the above movements are set into action through distoception (stimulation by energies whose source is at a distance from the organism).

The organic child's basic actions towards the energies of his surround are to first distribute the mass of his unsupported body around some vertical axis in alignment with the direction of gravity in a manner that will still leave his task-related parts or systems (i. e. eyes and hands) as much within the field of the task as is consistent both with his body structure and with the structural limits of the equipment for supporting him and also for supporting the task. Following, or concurrently with these actions, he also reflexly goes into action to align the coordinates of his body with the coordinates or frames of reference of the three-dimensional distributions of energies having to do with distoception, such as light, that are within the range of his sense organs. He also alters his tensions to determine a direction of movement that, if allowed to become overt, would change his relationship with other energy forms, such as heat for example, so as to balance his needs with that energy form if he were free to move (i. e. find a position where his heat output would be balanced by the amount of heat he could absorb). For optimum efficiency of task performance, all these shifts of relationship between the planes or coordinates of the body (transformations) and the discrete actions in relation to them should tend to carry the planes or coordinates of the body back towards a balanced or standard relationship similar to that described above for the child free of restraint and ready to perform (i. e. towards a transformation group, as the mathematicians might say). This new relationship of the body planes becomes the frame of reference for task performance, and the efficiency of that task performance is determined in great measure by how near the various shifts to environmental energies and restraints approach a transformation group, and by how much energy and body mechanism is necessary to maintain the balanced position with all these forces. To state it technically, performance efficiency is, among other things, a function of the cosine of the angles of the stimuli vectors from these various environmental forces, and the response vectors incited by them.

In the child's movements in relation to the above frames of reference, (together with the necessary structural organization of the energies and limits of the classroom surround to assure that these movements are at once efficient, and effective, in satisfying both basic biological and learning needs), lies the key to an adequate statement of architectural function for determining classroom design. It is regrettable that their description cannot be put into more simple and forceful words by the writer without destroying both their quantitative and qualitative significance to optimum learning, and optimum development of the child.

Only when these factors are incorporated in classroom design, (along with those having to do with instructional, psychological, and social needs and limits currently considered in planning our better schools), will our school plants be fully functional, fully adaptable to curriculum, location, climate and regional needs, and will they fully meet every requirement of a satisfying esthetics.

Just as supplementary services within the classroom must not interfere with the full and free actions related to critical biological tasks, educational and other services in areas outside the classroom must be planned in keeping with the physiological processes related to the activities to be carried on by the children in those areas. The whole school, the school and its site, must be integrated in a manner to provide adaptive transition, in terms of organic processes consistent with whole-child function, as the children move from outdoors to indoors, and from room to room. The desired achievement in plant design is full freedom of constructive physiological action as it relates to learning and development. How this is to be achieved is dependent upon the local educational planners, the local curriculum, the local resources, and the design ingenuity of the architect.

CO-ORDINATED CLASSROOM LECTURES

Lecture 2

AN OUTLINE OF A BIOLOGICAL POINT OF VIEW

Existing knowledge of the processes of growth, development, function, adaptation, and learning in the human organism is yet too limited to bring any discussion of even one of these processes to a closely knit, well-defined conclusion. What we know about these processes exists largely as isolated organizations of authenticated specialized data, connected together for the practice of the various applied fields concerned by large amounts of interpolated, or extrapolated, speculation so as to give us some semblance of a working whole.

For our purposes here, an outline of some of the known information in these fields would be of use in constructing a biological approach to classroom planning. Such an outline follows.

Section One

Human Beings As Organisms

1.1 The human being is a living thing, a mammalian organism, sharing the essential characteristics of all organisms.

- 1.1.1 The human organism, like all organisms, is dynamic; that is, it goes into action for certain purposes as a result of inner physiologic processes.
  - 1.1.1.1 Characteristic of all organisms are the processes of assimilating materials from the environment, transforming the energy of these materials, and using this energy for growth, reproduction, and establishing balances with the various forces and restraints in both its internal and external environments, (the basic protoplasmic functions of irritability, metabolism, and reproduction).
- 1.1.2 All human beings move through the same general pattern of sequential structuring in the growth process.
  - 1.1.2.1 Within determinable limits, every individual has his own unique configuration of this general pattern in terms of rate, timing, and synchrony of growth of parts.

1.1.2.2 The whole process is mediated by inner biochemical controls, but quality of the structures produced is markedly influenced by environmental forces.

1.1.3 As the individual progresses through the patterns of growth, he finds himself possessed of new physical resources determining his generalized behaviors in relation to the forces and restraints in his surround readinesses, and he is confronted by new demands from his culture and from his environment, which expands as a result of his new behaviors.

1.1.3.1 The human organism and its generalized behaviors are shaped, or specifically developed, by the processes of interacting with the physical and cultural surroundings in which the individual grows up.

1.1.3.2 "Development... is the adaptations that the organism makes to specific requirements of its environment while growth is taking place. In these adaptations the generalized systemic forms laid down by the innate patterns of growth are modified, or converted, into specific forms and patterns determined by environmental requirements."

Section Two

Organic Function and Adaptation

2.1 The function of dynamic energy systems (living organisms) is to promote their own integrity--to survive.

2.1.1 The basic process of survival is direction of movement, or change of relationship.

2.1.1.1 The processes of changing relationship, or directing movement, are facilitated with repeated specific movement or change of relationship.

2.1.1.1.1 Repeated stress, or repeated action, alters the structure or function of the action system concerned.

2.2 Organic integrity and survival are promoted in higher organisms, such as man, through specialized parts and systems, through a complex interconnecting system permitting various organizations of parts and systems, and through modification of structure.

2.2.1 "Survival is promoted by living forms through adjusting internal and external forces to hold those forces in dynamic equilibrium, and through modifying their structures from time to time, within the limits of internal equilibria, to better resist, or reduce, stresses produced in them by specific environments."

2.3 Specialization of parts, or systems, within the whole organism is solely to make more efficient the three primary protoplasmic behaviors which promote the organism's integrity and survival.

2.3.1 Specialized parts do not function independently. They function within the functioning of the whole. Their functioning, while definable in part, is inseparable from the functioning of the system of which they are a unit, and from the functioning of the total organism.

2.4 Modification of structure through function is the major portion of the processes of adjustment, or adaptation, of higher organisms and their potential, generalized behaviors to the requirements of specific environments.

2.4.1 "Superiority of organic form is apparently the product of... capacity for modification of various structures, as a result of function, within the limits of internal equilibria, so as to make function in relation to specific environments increasingly efficient."

2.4.1.1 The full discriminatory power of the various sense organs, the development of the full potentialities of muscle, the efficient contours of supporting structures, all result from use or function in a wide variety of specific and appropriate tasks.

2.4.2 "The child's body, or bodily systems, grows along the lines of stress induced in it by various activities, in order to reduce those stresses."

2.4.3 Modifiability of structure through function, in effect, records the results of the uses made by the organism of its structures in various combinations and actions, and the effect on the organism's total economy of these uses in various specific situations.

2.4.3.1 "The extent of man's nervous system and his capacity for modification of structure through function gives man the capacity to 'learn'."

2.5 Organic adaptation and modification of structure through function (with resulting alteration of function) is to the immediate surround, and it tends to be promiscuous from the social point of view.

2.5.1 The purpose of organic function is to satisfy immediate organic need determined by one or more of the basic protoplasmic behaviors.

2.5.2 Unusual, or excessive demands on function by the immediate surround can so alter structure that resulting altered function can be inappropriate, or inefficient in subsequent situations.

2.5.2.1 "If the forces impinging on the organism are too great for the organism's capacities; or, if the organism is restrained from acting towards them; or, if the environmental forces are distributed in patterns inconsistent with the organism's basic patterns of behavior for responding to such forces; or, if the organism is not in proper condition to meet ordinary forces...the organism is harmed."

2.5.3 Meaning follows, or is the product of, function in the human organism, and these acquired meanings direct subsequent behavior in a social direction only when function has satisfied organic need in socially acceptable behavior.

2.5.3.1 The direction of meaning towards social ends requires group control of total situations, so the function aroused by all the forces in the total situation can be directed into socially desirable behaviors, which satisfy all the organic needs to which those functions are related.

2.5.4 Unless the forces in the physical surround, the cultural demand of the learning situation, and organic function, can all be reconciled so that the child has freedom to perform his social tasks of development in a manner that will satisfy the biologic needs those tasks and their surroundings arouse, unbalanced modification of structures and of development can be produced, leading to later operational conflicts, distortions of sensation and performance, socially inefficient behaviors, or actual bodily breakdown.

Section Three

Educational Implications

3.1 Children learn through activity.

3.1.1 This is the basic concept in all modern curricula.

3.1.2 Today's educational programs largely interpret this concept through reading, writing, drawing, construction activities, or the performance of other tasks involving close visually-centered activities.

3.2 All activity, covert or overt, educationally purposeful or extraneous, from the organism's point of view is adaptive, or learning activity.

3.2.1 What the child will eventually be is the product of all the situations, or forces, which have set him into action, and thereby molded, or limited, his growth and development and the use he can make of his resources.

3.3 The child is set into action not only by the purposeful stimuli of curriculum, but also by all the social and physical forces and restraints existing in the classroom.

3.3.1 The distribution of light, as well as the task illuminated; the control of sound, in addition to the thing said; the design, or form of equipment for efficient and constructive body mechanics, as well as provision of support for a task; all enter into initiating the total actions of the child in school.

3.3.2 Physical factors and forces can be either constructive or adverse in promoting growth and development.

3.4 The child adapts physically in a manner much similar to his method of psychological adjustment: "The child grows along a line of stress to reduce the stress."

3.4.1 Innate growth patterns provide for development of a bilaterally balanced organism functioning around definable centers of reference.

3.4.1.1 Principle centers of reference are the lines of intersection of the medial and lateral planes of the head and trunk, and the lines of intersection of certain horizontal planes with these medial and lateral planes.

3.4.2 Static and stato-kinetic reflexes, functioning in relation to these centers of reference, provide balancing mechanisms for organisms against various environmental forces, and against the forces and movements represented in the action patterns of any task.

3.4.3 Visually elicited reflexes, both innate and conditioned, dominate or inhibit all other balancing mechanisms.

3.4.4 Visually induced gradients of activity, when not controlled to meet needs of organism, can be restraining and handicapping, resulting in limitations of learning, dissipation of energies, or even in warping of growth, development and well-being.

3.5 Successful learning through sustained close visually-centered activities is attained in action patterns at limits safely within, but constantly approaching, the maximum tolerances of the child for the bodily stresses these activities induce.

3.5.1 Even a limited amount of additional stimulation from poorly controlled physical factors or forces, continuing through a significant time, carries the child beyond his tolerances for body or systemic stresses, and leads to handicapping and warping strains.

CO-ORDINATED CLASSROOM LECTURES

Lecture 3

THE EVOLUTION OF STRUCTURE

Nature is an experimenter. Out of that basic constituent of the universe, energy, she has devised two types of structure--inorganic, and living matter. Each of these represent organizations of certain energies within the whole into energy systems that make for form and substance. Both are so organized, according to the fundamental laws governing energy, that their units operate towards the preservation of their integrity through certain mechanisms or patterns of maintaining internal and external equilibria. Both are limited in this function by those basic laws governing their organization, and both are subject to destruction or distortion when meeting external forces greater than the forces which maintain their integrity.

Inorganic matter represents nature's effort to organize energy into apparently stable substance--if not closed or static energy systems. Its primary forms are comparatively fixed, and their capacity to maintain integrity within the forces which surround them is dependent upon the stability of their internal forces. Primary inorganic forms unite with others only insofar as the resulting structure will make for greater internal stability and fix still further the energies of the uniting forms; and complex, unstable forms give off energy to disintegrate into simpler, more stable forms. The perpetuation of the integrity of inorganic structures and the adjustment of their relationships with external forces and forms, depend entirely upon the nature and extent of external factors.

Living matter,[1] on the other hand, represents nature's effort to create structure by organizing energy into open, or dynamic energy systems. Its forms are variable. Their capacity to maintain integrity within the forces which surround them is derived from capacities to adjust their internal equilibria, to utilize external energies or forms to alter their own equilibria or form, and to change relationships with external forces and forms so as to establish new balances with them.

These capacities for promoting integrity and adjusting equilibria are inherent in the way dynamic energy systems are organized to form the basic substance of living matter, protoplasm. Biologically, as distinguished from the physical or chemical actions on which they are based, these capacities can be classified as follows:

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[1] Recent research in ultramicroscopic forms, such as some of the viruses, points to the fact that there probably is no distinct break between inorganic and organic forms of matter. There are, most likely, intermediate forms, with many of the capacities of both types of energy systems, and there probably exists a continuum of forms from the wholly inorganic to the wholly organic.

1. Irritability, or the capacity to change physical relationship with external forces or form;

2. Metabolism, or the capacity to assimilate external energies or forms in modifying or repairing structures, or restoring internal energy balances; and, to reject those energies or substances which do not promote the structure's total economy, and,

3. Reproduction, or the capacity of living matter to create from its own energies or substances similar dynamic energy systems or structures.

Within the two types of organized energy systems which make for form, nature has created many physical substances and grosser structures--the ninety-six inorganic elements of the atomic scale and their molecules and compounds, and the millions of kinds of plant and animal life. Basic to each of these, however, are the fundamental laws governing energy, and the derivations from special organizations of these laws which are applicable to various or specific forms and structures and to their relations with other forms and structures.

It is generally recognized by biologists that the workings of all the gross parts of living organisms are entirely due to the reactions and interactions of the finer, microscopic units--the cells--of which all gross parts are composed. Modern experimental science is bringing forward striking evidence that all the operations of these cells are the resultant of the actions and interactions of still smaller particles within the cells. Experimental science is showing also that there seems no good reason to doubt that these constituent particles, in turn, are composed of the molecules of chemistry, whose properties depend upon the nature of those molecules. The properties of the cellular particles, as a result, depend upon the nature of their molecules and manner in which they have been related or combined to make up the particles. As the molecules are made up of the atoms of familiar inorganic forms, most complexly arranged, yet apparently not violating the laws of chemical combination and activity, it appears as though all living things consisted, in the last analysis, of a superlatively complicated dynamic organization of atoms, in which each individual atom is identical with similar atoms of inorganic substances and works wholly according to the same laws. In fact, it can be largely demonstrated that the capacities of irritability, metabolism, and reproduction inherent in protoplasm are but the gross expressions of the whole, produced as the atoms and molecules forming specific protoplasm function together according to the laws of physics and chemistry, in responding to the energies of each other, and the forces, and the energies of other substances, which surround the whole.

The seemingly miraculous attributes of living things, such as the powers of growth, development, reproduction, regeneration, sense reception, nerve and muscle response, thought, etc., --the processes of "survival" and "adaptation"--could be referable, not to any extraordinary characteristics of their atoms or cells in particular, nor to the intrusion of any mysterious "vital force" or new entity at any stage in the formation of protoplasm or the combining of cells, but rather to the marvelous orderly complexity in which the atoms and cells of living matter are arranged, so as to form a stupendously intricate structure of harmoniously interacting parts, functioning together for a more efficient realization of the three demonstrable behavior characteristics inherent in protoplasm.

Like inorganic matter, the function of dynamic energy systems, represented by living cells and their various combinations, is to promote their own integrity--to survive. That survival is promoted by living forms through adjusting internal and external forces to hold these forces in dynamic equilibrium, and through modifying their structures from time to time, within the limits of their internal equilibria, to better meet stresses produced in them by specific environments.

Throughout the history of life, chance has brought together various combinations of the basic structural material of life. These combinations formed structural associations, if they maintained equilibria more efficiently, or performed some specific act in a manner so as to better resolve some stress set up by specific environment. Since the beginning of life, nature, by means of mutation and selection, has experimented with these complex combinations of protoplasm. This experimentation has evolved various specializations of parts within these combinations so as to further assure or extend survival by making more efficient certain ways of adjusting to environments, or certain efforts to sustain or protect life.[1] More and more complex forms, capable of an ever-increasing variety of ways of utilizing protoplasmic irritability in responding to surrounding forces and forms, of metabolizing available substances and energies, and, of reproducing themselves, have emerged sequentially with the passage of time.

These complex forms, in turn, have undergone continual modification. Inappropriate or cumbersome forms or parts have disappeared, and originally inconspicuous features which led to adjustment or adaptation to changing environments have been developed further, by biological selection, to the advantage of the species. Interaction of environments and organisms has seemed to promote survival of those forms that have emerged through time which have been best equipped with special parts or structures facilitating basic protoplasmic functions by increasing the range of the organism's possible adaptations.

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[1] Just as a simple organism is organized to promote its own survival, so is a complex organism structurally organized. Specialization of parts or systems within the whole organism (i. e., nervous, digestive, visual, musculature, etc.) is solely to make more efficient the three primary protoplasmic behaviors which promote the organism's integrity and survival.

The development of special structures to promote survival in the surround in which species found themselves has followed two patterns of evolution. In one pattern, in addition to provisions for meeting certain minimum essential needs, this development has been through equipping the organism with special peripheral devices limited to protecting the organism from certain hazards. The quills of the porcupine, the shells of the crustaceans, the odoriferous equipment of the skunk, or the like, illustrate this form of development. Such peripheral structures are so specialized as to be in themselves the organism's direct protection against specific environmental hazards. They are much like shields to protect the organism from special forces or hazards which might be destructive to it. The organism has no control in varying the function of these structures, and it has but one form of behavior in relation to them--to retreat behind them when survival seems to be threatened.

In the second pattern of structural evolution, organisms have also been equipped with peripheral devices, but these have taken different forms than in the first pattern. These peripheral devices have consisted of specialized structures so sensitized as to be capable of detecting quantities or qualities and distributions of energies which in themselves could be significant to the organism's economy, or which could reveal the form of nature of objects or attributes in the organism's surround which might be related to the organism's survival. Other equipment consisted of supporting structures and motor devices providing mechanisms capable of shifting the organism's equilibria in a variety of ways. In addition, these peripheral structures of sensation and action were connected with a complex interconnecting system, or systems, which permit all or any combination of them to function together to provide appropriate actions of the organism for meeting changing requirements or hazards of the environment. The specialized sense organs, the arms, hands, and fingers, and the complex nervous system of man illustrate this second form of development. In this second pattern, the peripheral structures are more like tools for manipulating the environment to control the situations with which the organism is surrounded.

In the first form, shells, quills, or odor, offer little protection from more powerful, insensitive, or anosmic natural hazards. In the second form, however, with the variety of combinations and uses that may be made of the organism's peripheral structures, not only can protection be gained directly through some of those structures, but, with the acquisition of insight and meaning, the structures themselves can be used to manipulate forces or forms within the environment so as to provide the organism protection, and they also can be used to change the environment itself, so as to make it more favorable to the organism.

The permanence of an organic form and its relative position among other organic forms seems to depend, basically, both on the simplicity of its parts and the extent and variety of combinations and uses that can be made of those parts for the benefit of the total organism in various situations of a changing environment. In addition, superiority in the hierarchy of development of form also rests in the efficiency of the interconnecting system in organizing and equilibrating various combinations of peripheral and other structures to meet the requirements of specific situations, and the capacity of the organism's structures to undergo modification of form (cellular, systemic, or total), so as to fit better their original generalized or inherent forms or functions to the resources or energy stresses of specific environments. In other words, superiority of organic form is apparently the product of a combination of at least three adaptive mechanisms:

a. A minimum of peripheral structures which approach universality in their uses in meeting the organism's needs in its various environments,

b. A system, or systems, for the interconnection of these structures, and the other structures of the organism, which permit a maximum combination of actions of the peripheral structures while still promoting the internal equilibria of the organism, and

c. Capacity for modification of various structures, as a result of function, within the limits of internal equilibria, so as to make function in relation to specific environments increasingly efficient.

Such a combination of adaptive mechanisms provides the organism with the widest possible range of potential behaviors within an efficient total structure, with all the behaviors derivable from one or more of the three physically or chemically inherent functions of protoplasm--the basic structural material of all organic forms. In this combination, modifiability of structure, in effect, records the results of the uses made by the organism of its structures in various combinations and actions, and the effect on the organism's total economy of these uses in various situations. In this way, the latitude of possible behaviors may be extended by structures having been conformed through use to meet more effectively the needs or stresses of specific situations; thus, seemingly permitting recorded experience to be drawn on in meeting subsequent similar situations.

Modification of structure through function with its apparent recording of experience is the major portion of the processes of adjustment or adaptation of higher organisms and their potential, generalized behaviors to the requirements of specific environments. In addition to modification through specific function, the peripheral structures, as well as the total organism, are modified in overall form to some extent, by the resultants of all forces in the environments in which the organism grows or functions, in order to conform to those stress-producing forces and thereby "adapt" total form so as to reduce the energies expended in resisting or responding to the factors producing those stresses.

Man owes his superior position among organic forms largely to the variability of adjustive behaviors permitted by his structures. Man's principal system for interconnecting his bodily structures, his central nervous system, is much more extensive than that of other organisms, and his structures are much more modifiable in terms of experiences. The extent of man's nervous system and his capacity to "learn"; that is, to reorganize or change his behaviors on the basis of experience, to develop new skills through function to meet changes in his environment, and, as a result of awareness of cumulative modification through experience, to appreciate the natural and social phenomena occurring around him. Through these changes, he may select from a tremendous repertoire of possible modes of behavior those which can be effective in the manipulation of the material, the energy, and the social resources available to him at any given time. In this way, it is possible for man to protect and promote his economy under an enormously wide range of conditions.

Lower organisms live most effectively by using their structures or capacities exactly in the manner implied during evolution. Man's adjustive strength lies in his potential capacity to follow the line of behavior most apt to meet his needs in the particular situations in which he finds himself. Depending upon his capacities to "learn," upon the richness and satisfaction of his experiences, and upon the validity of the judgements he has formed, a man can project in imagination or thought a great number of special patterns of behavior and he can choose and put into effect the particular pattern which appeals to him as most appropriate and effective. Because of the equilibrating function of this interconnecting system, his behavior is subject to almost instantaneous inhibition and reorientation, if its imagined or even its preliminary consequences seem to show that it is inappropriate to accomplish the particular end desired. This is man's primary technique of adjustment, but it transcends mere adjustment. It leads to preparation by which man manipulates his environments in anticipation of special needs, and so makes the maintenance of his essential biological equilibria doubly assured. The human organism depends upon modifiability of structure through function (which is the basis of learning and its accompanying ability to evaluate past experience) as its way of adaptation. These capacities of man lie within the basic characteristics and functions of the organic material from which man is structured, as those characteristics and functions can be variously expressed through the nature and the possible combination of man's structures.

Man's superior position among organic forms results not only from his type of structures and the nature and extent of his interconnecting systems, but also because his periods on infancy, childhood, and adolescence are far longer than for any other organism, despite the fact that the duration of his gestation is not. Man undergoes considerable completion of structure during the periods subsequent to birth, and the greatest modification of structure through function is possible only while growth and structural completion is taking place. The potential capacities of bodily structures and systems can be developed only gradually in connection with their function, and generalized structures and their behaviors can be fitted for greatest operational efficiency in specific environments only as those structures and behaviors slowly mature while in use in those environments.

Early birth in the cycles of growth, and a prolonged period of development in the environments in which the mature organism must live and survive, provides man the basis for an opportunity for efficient modification of his potentially superior structures for optimum functioning in all the environments in which man must find his satisfaction. But the very factors which provide man the basis for this opportunity threaten his chances to profit by it in a social world.

Despite man's splendid adaptability, it must not be assumed that he can ignore nature's laws and still preserve the efficiencies or the well-being of his various structures that contribute to his adaptation. The basic characteristics of organic life remain unchanged. All organisms, from the most simple to the most complex, essentially are dynamic energy systems which always maintain their basic energy equilibria within the rather narrow limits prescribed by the laws governing the interactions of the physical and chemical constituents of living matter. This must be done despite the breadth of natural or cultural changes through which the organism must go and despite the widely varying demands for the expenditures of energy imposed by the external environment. Practically all behavior and modification of structure through function can be traced ultimately to the driving necessity for keeping the biochemical and biophysical processes of the organism from varying beyond the prescribed limits. The development of special structures and organs has not freed animals from the necessity for maintaining these equilibria; it merely has facilitated and given validity to the processes of protoplasmic irritability, metabolism, and reproduction by which the energy economy can be kept intact. This is as true of man as for the lower animals.

The human being makes effective use of the structures and capacities with which he has been endowed by nature only as those structures and capacities have been kept at optimum efficiency, and have been effectively developed and modified by function in an appropriate quantity and variety of experiences, controlled so he can form valid concepts about surrounding realities and action with which he has or may have to deal.

Man's insight into specific social demands and man's assumption of command over his adaptive processes in any given social environment or situation are not inherent, but are products of function--simultaneous socially significant and personally and organically satisfying function. Organically, the basic generalized behaviors inherent in structure are directed towards establishing equilibria between the organism and all the various physical forces, restraints, or energy distributions existing in the organism's surround in a manner sufficient to permeate appropriate sense organs and set the organism into action. Social utilization or social disapproval of any portion of these behaviors are only social concepts resulting from cultural man's convenience or inconvenience. From the objective viewpoint, that is, the viewpoint of the function of the organism, these behaviors are adjustments to, or of, the physical environment to sustain or protect life, or to promote the needs or interests of the organism. The social view and the organic view can be reconciled and social meaning derived by the individual only through appropriately stimulated, socially acceptable behavior that simultaneously satisfies all the organic needs aroused by the stimuli. Just as design follows event in democratic processes, meaning follows function in the human organism, and that meaning directs subsequent behavior in a social direction only when function has satisfied organic need in socially acceptable behavior. Organic adaptation and modification, or structure with resulting alteration of function, tends to be promiscuous from a social point of view. When the organism acts to adjust its balances to forces impinging upon it, if those forces are intense enough or exist long enough, structure is changed to better meet those forces. The organism reacts and conforms to all the effective forces in its surround, not merely to the socially purposeful ones. If part of the stimulus to act is set up by social forces and part is due to chance or uncontrolled physical factors, the resulting modification of the organism and its subsequent alteration of function is not due to one or the other alone, but is due to the resultant of both of them. Because of this, the social viewpoint of behavior and the biologic one can be in conflict, and such conflicts can be damaging to the organism. For example, one of the biologic functions of vision is to establish organic balance with all the brightness contrasts existing in the visual field. The principle social function of vision imposed on the organism is the communication of the meanings society attributes to certain brightness contrasts, such as the contrasts between type and paper on a printed page. If society should teach reading to the developing child by being concerned with only the brightness contrasts on the printed page and only the actions they elicit in terms of the socially defined meanings of the printed symbols, ignoring the distribution of all other brightness contrasts existing in the child's visual field while reading is going on, the resulting adaptations from such a specialization of total function might be such that the child could perform efficiently only in the classroom task or situation because his structures had been modified in a manner to fit only that surround.

Also, the conflict between task contrasts and extraneous contrasts could negate the child's learning capacities, or, and more often, because extraneous contrasts were far the greater force in determining organic function, systemic and intersystemic structures could be so warped through conflicting function aroused by these contrasts and the compulsion of the task that the organs specifically concerned with symbolic communication could be functionally, if not structurally, damaged for all other visual tasks--efficiencies in other performances could be lowered and many of the potentialities of the child might be lost to society's ultimate detriment.

Man, through the nature and extent of the nervous system and through the evolution of his superior structures for manipulation of his environment, ranks first among all organic forms in potentialities for adjustive behaviors which could solve the problems of his destiny. But, unless man's culture and organic function can be reconciled so that he has freedom to perform his social tasks of development in a manner that will satisfy all the biologic needs those tasks and their surrounds arouse, the very organic mechanisms that make for his potentialities can defeat him in adapting to even his most simple social problem.

CO-ORDINATED CLASSROOM LECTURES

Lecture 4

SOME PRINCIP~~AL~~LES OF GROWTH AND DEVELOPMENT

The child at birth is incomplete in both the size and structure of all of his bodily systems. The state of completeness he will eventually attain in these systems is determined by two processes--growth and development. These processes, to a considerable degree, also determine the systemic and total efficiencies--physiological and psychological--he will eventually reach.

The processes of growth and development are far too complex to wrap up their definitions and descriptions into neat little packets. (And there is still too much research in growth and development yet to be done even to begin to classify the packets we might have if it were possible to simplify our statements on these processes through tightly compartmentalized bits of information.) Nevertheless, some working concepts on growth and development are necessary for our purposes here.

The material presented here is solely for the purpose of giving the reader and the author a common starting place for discussing some phenomena occurring in children engaged in the sustained, close visually-centered activities of the classroom. It is presented with the full recognition that any brief statements on growth and development must be arbitrary and incomplete. However, it is hoped that these statements will be taken as being consistent with Gesell when he said, "to dissect children into fragmentary items does violence to the reality of the child's nature and is justifiable only if the process results in a clear understanding and interpretation of the total flow of activity."

Our first problem is one of definition. The terms "growth" and "development" are used with a slight difference of meaning in medical literature than that given them in most of the literature concerning learning processes, although both uses of these terms are derived from the same concepts.

Kugelmass[1] presents a good summary of the medical use of these terms when he says: "the processes of growth are two-fold--developmental and anabolic. Developmental changes involve proliferation or division and increase in the number of cells; differentiation or specialization of structure; and organization or segregation according to structural and functional properties. All true growth, normal, abnormal or pathologic, is the resultant of these three fundamental processes characterized by specific chemical reactions. These are distinct from the processes involving anabolism or increase in size, weight, or mass, for incorporation of new material into that already present is not an essential accompaniment of developmental processes per se. Developmental functions produce an increase in the number of cells, or division of their substance, and bring about structural and functional specialization into effective aggregates. Although development may take place without increase in size, weight, or mass, growth toward the complete and maturely functioning organism is dependent upon processes of anabolism. Growth is thus the expression of the combined action of the developmental processes of proliferation, differentiation and organization and the metabolic process of anabolism. . . . Growth continues until the production of a certain number of cell units is complete although the basis for this finite number is not vested in the inherent power of growth."

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[1] Newton Kugelmass, The Newer Nutrition in Pediatric Practice, J. B. Lippincott Company, Philadelphia, 1940.

"Growth. . . is most intense before the master activities of gland, muscle, and nerve are established. As growth proceeds to its limit, activities of gland, muscle, and nerve become possible. The impulse to grow ceases while these activities continue throughout life. . . . Growth is self-regulatory. It keeps with some variation within well-defined limits . . . . Cells grow actively until a particular organ reaches a certain size and completes a definite inherited pattern. . . . Then growth-regulating factors assume control with the result that growth processes in the cells are reduced to a minimum sufficient only to repair incidental wear and tear."

For our purposes here, growth is the term used to designate the processes of completion of a certain portion of the size and structure of the bodily systems through biochemical activity that has been biochemically initiated by virtue of the incompleteness of those structures. In other words, molecular, cellular, and systemic incompleteness creates a biochemical instability which incites biochemical activity towards completion that persists until stability is approximated. The upper limits of growth are determined by, (1) inheritance, (2) nutrition, (3) disease or trauma, (4) previously attained growth, (5) in any system, by the growth of other bodily systems, and (6) "development," not only as that term is used by Kugelmass, above, as part of the growth function, but also as it is used below in respect to adaptation and learning.

The child grows as a whole, but he does not grow synchronously with respect to all his varied parts and systems. He may be lagging in one field and accelerated in another. Growth follows certain innate patterns determined by the initial structural material of the organism (the fertilized ovum) and by systemic and intersystemic imbalances; and, each pattern has a relative upper limit in time.

In addition to the processes of proliferation, differentiation, and organization mentioned above, from the learning point of view, development also involves the modification of growth by the activities and experiences through which the organism goes. In other words, it is the adaptation that the organism makes to specific requirements of its environment while growth is taking place. In these adaptations, the generalized systemic forms and functions laid down by the innate patterns of growth are modified, or converted into specific forms and patterns determined by environmental requirements.

Development in the above sense as contrasted to growth, is principally a biophysically initiated process although it involves biochemical activity after initiation. Development is limited by (1) the inherent capacity of the organism to perform, (2) environmental limits, (3) previous experiences, (4) the state of the total organism at the time of any experience: (i.e., a. its organization, b. disease or trauma, c. growth achievement), and (5) nutrition.

From birth to maturity, the child, from a dynamic point of view, is a totality which is constantly undergoing alteration to maintain an integration of parts which are in many and various stages of completeness in their own growth and development. The slightest distortion of any of these parts deforms or limits the growth and development of the whole.

The problem, then, of promoting optimum growth and development is one of controlling, simultaneously, systemic growths, intersystemic integrations (both functional and organic), environmental demands (natural and social), and the order of experiences, in such a way as to preserve and promote total efficiencies, both biological and social.

The full development of the child's potentialities can come only through use or function. This functioning, however, must wait upon organic, psychic, and experiential readiness. It must be appropriate to the biologic purpose of the organs, bodily systems, and capacities activated, and it must have relationship to the needs and purposes of the organism as a whole.

Growth produces progressive changes in structure with accompanying and closely correlated changes in function. At various times in growth, certain structures or combinations of structures reach points in completion where it is possible for the organism to react to stimulation in ways in which it could not react previously. These various points in growth are designated maturities, and they determine certain generalized responses, or possibilities for performance. They do not, however, determine specific social behavior. For example, a child will respond to stimuli leading to standing and walking when neural, skeletal, and muscular growths attain the proper maturity. However, these maturities will not lead the child to walk purposefully to some place. To walk purposefully to some place, the child must learn--through experience or activity--the advantages to him of walking to that place, and his structure must be modified through this activity to permit him to walk to that place so that the end gained will have greater value than the energy, or effort, put forth. Learning is largely a biophysically initiated biochemical change which leads to specific efficiencies in adaptation. Development includes this learning plus the modification of the total physiology or function involved in any specific performance as adaptation simplifies the actions required by that performance.

Development can be negative as well as positive, and it can be pathologic in its end-result just as much as it can be advantageous. Atrophy through disuse could be an example of a negative end-result of development; while a pathologic end-result could be illustrated by the adverse alterations of visual function which can take place when an individual is placed in a sustained visually-centered task inconsistent with the biologic purposes or mechanics of vision and seeing.

Behavior, for our purposes here, is the activity that is released when sense organs are stimulated adequately; that is, when the energy of stimulation is sufficient to excite them so that a related neural discharge is instigated.

It does not take too elaborate an examination of the organism to see that systemic organization is such that intersystemic function is biologically intended to preserve the integrity of the organism. Sense organs have evolved to promote survival by making the organism aware (through setting it into action) of factors in its environment affecting its biochemical or biophysical equilibria, and these sense organs are connected in such ways that, when stimulated, activities are set up which are directed towards changing relation of the organism with the source of the energy of stimulation, or towards promotion of more satisfying equilibria. These activities are so directed that, when equilibrium has been approached or attained, they should put the organism in such a relation to its environment, or into such a form through structural or functional alteration, that survival has been promoted. To illustrate--a situation exists in the individual's immediate environment which is a threat against the individual's survival and some factor directs force or energy in this situation towards the organism in sufficient intensity to permeate the thresholds of appropriate sense organs. The neural activity set up by this sensory stimulation disturbs the biochemical or biophysical equilibrium of all of the body mechanisms reached by that neural activity. The organism then goes into action to restore this biological equilibrium. The action brought forth is of sufficient intensity that, if properly directed, it would change the organism's relationship to the source of stimulation in such a way that biophysical equilibrium would be restored and the factors of stimulation would no longer be stress-producing to the organism.

Many types of adjustment are represented by this pattern of behavior. For instance, a disturbance of the center of gravity of the body stimulates the vestibular apparatus to produce a mechanical adjustment of the body to the pull of gravity by shifting the body into a posture that can be maintained with "least" effort. Sound or light stimuli produce a rearrangement of the head or body to promote adequate visual or auditory centering on the apparent source. In either case, if the body balance is restored, or the sound or light does not continue, no further activity is brought forth. If no balance is achieved or the sound or light pattern persists as an adequate stimulus, additional activity is set up, as a result of the continued tension, and this activity continues until some form of adjustment is made, or until interrupted by other more immediate forces.

Responses to stimulation take a number of forms: Among these are the immediate reflex responses that restore equilibrium without sustained activity, and the serial responses that are elicited by a series of mechanisms put into action as a result of a stimulus. In the reflex responses, there is little alteration of structure or function if adjustment is complete at the end of the immediate response. In sustained activity there can be, and generally is, structural or functional alteration.

There are three processes (among many others) entering into growth and development which, if properly controlled by those in charge of the child, contribute to attaining optimum development. If these processes are not fully understood by those in charge of children they can, and do, limit growth and development and enter into the production of growth and development difficulties or deviations. These three processes are the activity of the autonomic nervous system, conditioning in general, and shifting of gradients of growth.

In addition to its specific functions in visceral and other activities, the autonomic system has two distinct functions in any intersystemic organization promoting the welfare of the organism. Environmental situations of such intensity or type of stimulation that they seem to threaten the welfare of the organism produce bodily organizations, through the mediation of the sympathetic portion of the autonomic system, that lead the organism to attempt to destroy, change, or get away from the situation. Environmental situations of a type of stimulation that they seem to contribute to the well-being of the organism produce bodily organizations, through the mediation of the parasympathetic portion, which lead the organism to attempt to sustain the situation or preserve the status quo. In other words, from a survival or a social behavior point of view, there are only two fundamental patterns of performance--avoidance and adience--either destroying or moving from the situation physiologically, or preserving the situation physiologically or psychologically.

The individual's apparent behavior, at any given time, is roughly the algebraic sum of all his impulses. If there are elements existing in his total environment at any given time which arouse in him a different autonomic mediated activity than the activity or feeling tone which society says should be associated with the purposeful part of the situation, then the individual's behavior can be deviating or socially pathological. When we recognize that sustained or repeated behaviors produce a definite physiological change in the individual leading to the repetition of the behaviors in similar situations, we can see how a failure to recognize and use or direct the autonomic activity going on in the individual during certain experiences may lay the foundation for alteration of growth and development. Threats made because of nonaction or inappropriate action of the individual in social situations; the production of psychological tensions during meals; forced sustained activity without insight into purpose; intense big muscle activities after meals and similar errors of scheduling, are all examples of conflicting autonomic experiences that lead to distortion or damage.

Conditioning is a process that is spoken of glibly in organized activities intended to modify the behavior of children, but it is a process that, in most instances, is not fully understood and controlled. As a consequence, directed conditioning has as often led to distortion and damage as it has to optimum development and acceptable behavior.

Two fundamental laws of conditioning, namely, "conditioning takes place in the organism whenever two or more activities exist at the same time," and "conditioning is irrational and takes place in spite of the desire of the individual," both illustrate why pathological outcomes are possible without thorough control of the experiences of the child.

If a teacher, for instance, is leading the child through a group of performances that have as their desired end-result the preservation or acceptance of some situation, and this is done at the same time that the child is suffering from a pain which he is sympathetically organized to avoid, and the avoidant impulse is as great or greater than the attitudinal impulses stimulated by the teacher, we have a conflicting situation and unhealthy conditioning. Through conditioning the child is learning really to avoid the thing the teacher is teaching rather than later to do willingly the performances being taught.

Conditioning is a process of physiological change that takes place whenever two or more activities are carried on simultaneously, and the change is such that after the initial experiences, any of the stimuli existing in the initial situation will elicit all of the independent responses brought forth in the initial situation. In the example cited above, when the child later meets the stimuli that the teacher introduced, the responses that pain produced will be elicited just as well as the performances that the teacher had directed. Because of the differences in intensity, the purposeful response will be limited to the difference between the two impulses, making for inefficiency, or if the pain response was great enough, thereafter the purposeful response will be inhibited entirely.

A number of things have to be taken into account in directing conditioning. A child, meeting a learning situation for the first time, reproduces exactly what he senses and learns exactly what he reproduces. Both of these are subject, of course, to limitations of maturities or pathologies in sense organs, organs of mediation, and in motor organs. If an individual child has sensory or motor limitations, or is suffering from tension or other difficulties, then his learnings will be distorted by those difficulties or limitations. If his difficulties or limitations are such that they arouse autonomic activity when the defective organs are called into play, then we have an intensification of distorted learning. If the autonomic activity aroused is different from that which society desires, then we have not only a mal-learning because of the distortion produced by the defects, but we have also a socially conflicting feeling tone or attitude, and a resulting delimitation of, or a tendency towards, distortion or deviation of growth and development.

Purposeful conditioning should be concerned with integrating the generalized activities aroused by the stimuli in any situation and directing the behavior brought forth into specific forms that satisfy social requirements while still restoring the biological equilibria that has been disturbed by the total stimulation. To control purposeful conditioning properly the one directing the child's development must have full knowledge of all of the significant processes going on in the child, and of all his significant biological needs and capacities at any given time. Partial knowledge limits the activities of those in charge of the child merely to being concerned with the immediate systems that enter into the purposeful part of the stimulation, and lead them to ignore the activities that are being aroused simultaneously by stimuli in the situation that are extraneous to the immediate educational purpose.

To provide for optimum growth and development, purposeful conditioning must be the linking of a group of stimuli and their accompanying responses to produce certain desired behavior patterns which thereafter will simultaneously satisfy biological needs, psychological purpose, and social requirements.

A study of the gradients of growth shows that the center of growth, at any given time, is at the center of the greatest activity. In the child who is growing and developing normally, then, the centers of activity--whether biochemically or biophysically induced--should always be those centers that are laid down by the innate growth patterns. Biophysically induced activity incites biochemical activity. If the centering of biophysically induced activity is different from the centering of the biochemical activities that are completing growth patterns, there will be a structural conflict between the growth taking place at the action center and that taking place at the normal center. Such shifts in gradients, if they persist, can only produce asymmetrical developments that lead to later operational conflicts, distortions of sensation or performance, or actual breakdown.

What has been said probably can be summed up in a number of principles that should be utilized in promoting optimum growth and development:

First, lack of maturation, of readiness for specific performance, or of the freedom to perform, shifts the gradients of growth or alters functioning through conditioning.

Second, overuse of misdirection of energy alters function or shifts the gradients of growth.

Third, adverse shift of gradients of growth or alteration of functioning through conditioning, affects the efficiencies of the individual and limits or distorts his subsequent growth and development.

As general principles these can be stated as follows:

Anything that retards, accelerates, or distorts the innate processes of maturation lays the foundation for developmental deviation; and any factor in the child's environment creating stress or tension in him, beyond his matured capacities or in excess of his physiologic tolerances, lays the foundation for developmental deviation.

CO-ORDINATED CLASSROOM LECTURES

Lecture 5

A Dynamic Point of View

Part One

Arnold Gesell, in his studies of visual development in children, points out that every child organizes his space world (learns the meaning of things and the world around him) in three basic biologic fields:

(1) SKELETAL, in which he seeks and holds a visual image; [1,2] (i. e., he reflexly reacts to light stimuli, through skeletal and central innervation and musculature, to secure the most physiologically appropriate projection of the light pattern on the retina (and to secure the best body organization for readiness to respond to that light pattern) by adjusting accommodation, convergence, and total posture in keeping with those required by the gradients of the light pattern.)

(2) VISCERAL, in which he discriminates and defines the image; (i. e., he makes certain biochemical and biophysical adjustments between his current visceral needs and the somatic requirements initiated by the light stimuli--adjustments mediated by the autonomic nervous system. These visceral-somatic adjustments produce feeling tone which provides the basis for attitude towards the stimulating situation by evaluating, in effect, the physiologic cost or organic significance of the bodily actions aroused by the external stimulus.)

(3) CORTICAL, in which he unifies and interprets the image; (i. e., representations or resultants of the neural signal patterns of the external stimuli; of the proprioceptive signal patterns from the motor responses made to the external stimuli; and, of the signal patterns of the visceral-somatic adjustments from accompanying autonomic actions are carried upward to higher centers where they are integrated; individually and collectively scanned for comparison with the retained or stored patterns of previous experiences; and again integrated with the resultant similarities of past experience determined by the scanning processes. The signal patterns modified by these integrative and scanning procedures are then (among other processes) transmitted to motor centers to be imposed upon

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1. Within the present writer's understanding of the term, in this use "visual image" should not be interpreted merely as the organization of the light pattern projected on the retina. It should include, among other things, all the perceptual factors related not only to the light pattern and characteristics, but also to the behavior patterns set into action by the stimulus.
2. The underscored phrases only under (1), (2), and (3) are Dr. Gesell's. The parenthetical interpretations are wholly the current writer's.

the original signal so as to inhibit the original behavior, or to modify or redirect it in whole or in part in keeping with total needs and with past experiences.)

Dr. Gesell further emphasized that these three fields develop jointly, but by no means uniformly--the ratio varying with the advancing states of the individual child's growth.

While the three biological fields, discussed above, which enter into the organic aspects of deriving meaning from experience are related to visceral development, similar processes enter into the acquisition of meaning and the redirection of behavior in respect to other modalities.

So far, in these lectures discussion has been confined largely to the first field, the skeletal, with some reference to the significance of the second, or visceral field. While the cortical or higher functions, in the last analysis, are probably what set man apart from the lower orders, and no study of human development and learning would be complete without a thorough exploration and appreciation of higher functions insofar as data are available, nevertheless the three fields DO develop JOINTLY as Dr. Gesell says, and, in a significant respect, each is a function of the other.

A probably unfortunate selection of everyday terminology has been made for the orders into which these three fields of function are commonly grouped. Most of the processes falling within the skeletal and visceral fields are ordinarily referred to as "lower" functions, while cortical processes are labeled "higher" functions. The culturally connoted meanings of the terms "lower" and "higher," emotionally and erroneously derived from the biologic concept of "lower" and "higher" orders of organisms with man as the "highest," makes it too easy to lose sight of the fact that the terms merely indicate a hierarchical[1] or sequential arrangement of necessary and joint functions.

Because basic biologic behavior, inherent in structure, is directed towards reducing internal tensions and establishing equilibria between the organism and all the various biologically significant physical forces, restraints, and energy distributions existing in the organism's surround, this behavior in its generalized, undirected expression, from the organism's point of view is amoral and asocial. However, from the social group's point of view some of the expressions assumed in these behaviors are inconvenient for the group or differ from the group's standards, and,

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1. Probably even the term "hierarchical" needs explaining. It is used in this sense to mean an order in which the complex, total, or higher function is partially derived from, or has among its components, the lower or simpler functions.

as a consequence are labeled "promiscuous," "animal"--or, "low." Man, as an organism, shares in common with the lower orders most of the lower functions and tends to express many of them, when undirected, in much the same manner as do the lower organisms. What is commonly not recognized as the difference between man and the lower organisms is that, in man, the expression of potentially socially-significant lower functions can be redirected through experience so as to contribute to the group's convenience or advancement, while in most of the lower orders it cannot.

This emotional toning of terms leads too readily to the fallacious reasoning: "Man is of a 'higher' order, hence man, having 'higher' functions, can ignore or suppress his 'lower' ones," or, "Man's 'lower' functions, being dominated and controlled by his 'higher' functions makes it possible to control man's behavior and direct his development through a direct approach to his 'higher' functions alone." This would certainly simplify the practice of the arts and sciences related to human learning and well-being, if it were true--but it just isn't so.

The functions concerned are joint ones, none of which can give way to the others without damage to the total organism. The processes involved are equilibrating ones, with the higher functions acting as the synthesizing and directing mechanism in reorganizing and redirecting the expression of the lower functions in keeping with the organism's primary and symbolic experiences, while not altering the biological purpose of the lower functions or defeating them in meeting the organism's biologic needs. This constant redirection of expression takes place in order that all the needs of the total organism, biological, psychological, and social, are met in a specific environment. Through this redirection of expression, as a result of the operation of higher functions, there can be further refinement of expression, thereby continuing the promotion of the organism's total economy in all the surrounds in which it finds itself.

Because of a growing understanding of the function of the higher centers in man (and because of the vast amount of data related to these functions that is presently being dropped into our laps through current emphases on psychological and psychiatric factors in psychosomatics) there is danger at this time of our becoming, in effect, atomistic as a result of our very efforts to become holistic--that is, to understand the whole man. Current researches, and experiences with current techniques in areas having to do with human development and behavior are tending to lead us towards over-emphasizing the place of the psychic as a determinant in human adjustment or malfunction and ignoring the somatic in our efforts to become more psychosomatic in our approach.

The presence of higher functions in man has not excused him from satisfying the lower functions--higher functions have merely increased the validity of the lower functions and the range of interpretation that can be made from their actions. Distortion of the lower processes away from their primary purpose actually threatens the validity of the higher ones. For these reasons, while in no manner depreciating the need for an understanding of these higher processes and for use of techniques based on our knowledge of them, for a sound approach to directing the growth and development of children we should thoroughly understand what is known of the first two fields of organic function before entering into an elaborated discussion of the place cortical function occupies in behavior and development.

Before we leave the subject of "higher" and "lower" functions, it might be well to examine a few of the mechanisms and processes involved in these functions in the light of Gesell's three fields which enter into the organization of the individual's space world. In this connection let us first re-examine in outline some pertinent points concerning these mechanisms and processes that have been presented previously.

1. ORGANIC PURPOSE (survival through preservation of the integrity of the total organism) is promoted through shifting position and relationships in the space world; through adjusting internal and external forces to hold those forces in dynamic equilibrium; and, through modifying structures within the limits of internal equilibria to better resist or reduce stresses produced in them by the forces or restraints of specific environments.

The primary survival function of the organism is to move towards establishing a series of physical and chemical balances within itself, in its environment, and, between itself and its environment.

2. BALANCE, in an organic energy system falls into two classes: Static Balance, and Dynamic Balance.

(a) Static Balance provides the necessary support for action, but it does not produce in the sense of promoting all the essential shifts required by the organism's economy. However, it does provide the frames of reference from which the organism can function and which are essential if the organism's actions, functional redirections, and structural changes, made to preserve its integrity and promote its economy, are to be successful through time.

These frames of reference are represented by the systems of three-dimensional coordinates, and the mathematical functions upon them, of certain structural limits and inertias, certain actions against forces of fixed direction and nature, and, certain counter actions against manipulatory movement.

Modification, or redirection of the functions or the structures related to static balance in any manner other than making them more efficient in their essential purpose of support for action in the environments in which the organism finds itself, can do nothing but delimit or destroy the organism's efforts to preserve its integrity.

(b) Closely related to static balance in dynamic organisms free to move through space, are actions which tend to center the organism on the vectors or gradients of those forces in its surround which are related to the organism's economy. If action is to be efficient, there must be not only frames of reference from which to function, but also frames of reference to function towards. These two types of frames of reference must be brought into such a relationship through deliberate design of the artificial environment that the environmental vectors setting the organism into action and the organic vectors they arouse provide physiologically appropriate axes of function leading both to optimum identification of the organically significant aspects of the stimulating force (such as magnitude, direction, relationship, source, and the like) and to economic establishment of an adequate equilibrium between the environmental force and organic response. In addition, the transformations and transformation groups on both the environmental and the organic systems of coordinates defining the actions needed must describe actions within the capacities and tolerances of both the organism's structures and behaviors, and must not adversely affect other necessary actions of the organism in relation to other environmental forces.

Organic structures for these centering actions are represented by graded distribution of receptors; distribution of receptors of unequal sensitivity in sense organs in such a manner that areas of greatest discrimination (and least sensitivity to the energy of stimulation) fall approximately on the axis of function of the organism in relation to the sense organ; bilaterally-paired receptors; accessory apparatus for shifting the axes of paired sense organs; mechanisms of bilateral reciprocal action which tend to shift the spatial orientation of the organism until the stimulating energy is distributed equally over receptors on the two sides of the organism, or is distributed in equilibrium over multiple-receptor sense organs in relation to certain fixed axes of reference; dual effector systems; etc.

Centering structures can be modified, or redirected in function, to center the organism on psychologically or socially determined tasks. However, such modification or redirection does not excuse the structures from their basic biologic function of centering the organism on the total energy density distribution falling within its field of sensitivity. These psychological and social modifications and redirections of centering are most commonly accomplished (and in most cases can only be accomplished) by conditioning-in counter-actions or stresses which stop the overt movement of the organism or its essential parts, (as they rotate through space towards a centering on the energy density) at that point in space where the organism will center on the psychologically or socially designated task, rather than go on to center on the energy pattern.

Depending upon the nature, intensity, or pattern of distribution of the energy and the duration of the task, these conflicts of function between physical need and social or psychological requirement can create adverse torques and torsions or other restrictions of function, and unreduced tensions which delimit or alter the performance of the task; can alter or reverse the affective experience or feeling tone essential to deriving the socially defined meaning attributed to the task; can alter sensory distribution of the energies of stimulation from the task, thereby altering both essential perceptions and the action patterns required by the task; can dissipate the organism's energies needed for other functions; can warp structure by restricting its adaptations to only the effective performance of that or similar tasks and only in the manner in which the task was performed in the specific environment of adaptation; and, can break down structure.

In summary, when various environmental forces of significance to the organism are encountered, they are detected by appropriate sense organs (i.e., light by eyes). The effect of these forces striking their related sense organs is for the body to organize reflexly the necessary motor and other equipment needed to react to balance the body to the forces, mobilize the necessary energy for this action, and then set the balancing mechanisms into motion. If the outside forces have certain characteristics of intensity or duration, or are not offset by the first reflex balancing action, additional activity is set up to identify the factors in the environment in more detail, analyze their meaning to the organism's economy, and set up additional appropriate action directed towards adjusting to them. The organism constantly tries to shape itself and its internal balances to the forces in its particular surroundings so as to reduce the stresses set up in it by those forces, thereby conserving its energies for use in meeting other vital needs and purposes.

If the forces are too great for the organism; or, if the organism is restrained from acting towards them; or, if the forces are distributed in patterns inconsistent with the organism's basic patterns of behavior for responding to such forces; or, if the forces are prolonged unduly, thus requiring energies to offset them which the organism needs for other purposes--the organism is harmed.

(c) Dynamic Balance is productive balance. . It is the organization of various actions that translate the energies and forces of the organism into patterns of behavior directed towards achieving all the purposes and needs of the organism created by specific environments, both external and internal. It does not and cannot involve the establishment, externally, of a static relationship of the organism or its parts with a fixed point, plane, area, or other function of space, nor internally can it be directed towards establishing neutralization of energy through creating rigidity of structure. It is, rather, the direction and organization of force and counter-force, action and reaction, so as to approach a statistical equilibrium among them. Externally, the organism in its dynamic aspects utilizes points and other localizations of space around which to function in establishing these statistical relationships with the actual and apparent forces and attributes of the surround through changing or altering its position in its space world, or through manipulating the factors, or the symbols of the factors, of that space world. Internally, the organism functions in a similar manner to establish statistical equilibria around the gradients and functions of biochemical and biophysical action.

The mechanisms related to dynamic balance with the space world are all those organic mechanisms necessary for determining the significant attributes and characteristics of the surround together with their associated mechanisms for changing the organism's position in space and manipulating the factors and symbols of space--the three groupings of mechanisms enumerated by Gesell which were cited earlier.

Within the limits of their construction and organization, the structures related to dynamic balance can all be modified or redirected in function, and such modification is not only necessary, but takes place constantly in adapting the basic and generalized behaviors of the organism to the specific surrounds in which it finds itself. However, in assaying or purposefully directing the modification of form or reorganization of function in these structures, certain principles must be borne in mind. First, the essential body mechanics inherent in the organization of the total organism and necessary for the preservation of its integrity cannot be violated if optimum total functioning on any level is to be kept intact. Structures used in common in various functions must be maintained in a state permitting efficient expression of all the functions. Gradients of various actions must have common centers with, or fit the frames of reference of associated or concomitant actions. Unilateral actions must be counterbalanced with equivalent expression of force on the opposite side. And many similar principles can be derived from studying the mechanics of the total structure.

Lecture 11

AN OUTLINE OF VISION AND SEEING

1 "Seeing," organically, is the detection of differences in the way light is distributed over the various parts of the environmental field encompassed by the eyes.

  1.1 Seeing is essentially the organic function of brightness differences and brightness contrasts.

  1.2 It is the sensory portion of a total behavior pattern, or patterns, related to, or elicited by, differences in light distribution.

  1.3 From the viewpoint of educational planning, seeing is only of significance in terms of:

    1.3.1 The minimum and optimum brightness differences and contrast values which are necessary, at various developmental levels of the child, for the detection of light distribution patterns that are culturally and personally meaningful.

    1.3.2 The minimum quantities and the qualities of light which are needed to maintain, economically, those meaningful patterns of brightness differences and contrasts; and,

    1.3.3 The pathologies and functional deviations which might exist in individual children that would interfere with the educationally adequate detection of those meaningful patterns, together with the earliest possible detection of such children, the direction of them towards satisfactory correction of their difficulties, and the adjustment of brightness differences and contrasts to meet the needs of those children with difficulties that have not been, or cannot be, corrected.

2 "Vision," from the viewpoint of learning, is the adjustive, or adaptive, action aroused by a pattern of light distribution. It is the total behavior of the organism elicited by a pattern of brightness differences, or contrasts.

  2.1 "The child does not see to see; he sees to act."

  2.2 The meanings attributed to certain light distribution patterns, such as the brightness differences, or contrasts, between the type printed on a page and the background of the paper making that page, or the visible outlines and contours of an object or form, are not innate with the organism, but are defined by society and must be learned by the organism through educational direction of its experiences in adjusting, or adapting, to light distribution patterns.

2.3 The physiologic functions of light and its patterning into brightness differences and contrasts by the organism's surround can be summarized much in the following order:

2.3.1 Promoting the organization of the body's readiness to adjust, or perform, in terms of the brightness contrasts, or objects in the total visual field which are related to the body's economy;

2.3.2 Aiding in the spatial orientation of the body and its balance with the immediate forces in its environment;

2.3.3 Initiating reflex adjustments of the eyes, head, and total posture of the body so as to promote efficient resolution and efficient reaction towards contrasts, or objects in the visual field related to the organism's economy;

2.3.4 Directing final and efficient resolution of the visual image;

2.3.5 Incitation of the visually-determined responses the body's economy requires towards the image resolved and perceived.

3 Both vision and seeing are tridimensional functions, and their three dimensional nature must be taken into account in educational planning for visual-centered activities.

3.1 Because the organism reacts as a unit in performing these three dimensional functions, classroom planning must coordinate all the factors affecting and effecting optimum freedom of performing purposeful visually-centered tasks into a unitary three dimensional surround (i.e., the coordinated planning of light sources both natural and artificial, decoration, the optical aspects of educational materials, seating and other equipments, etc., so as to meet the total developmental needs of the child in his visually-centered experiences in a three dimensional world).

3.1.1 Vision, for example, not being merely acuity and identification, cannot have as its lighting requirements the maximum quantity of light to promote maximum resolution of details restricted to a plane surface. Such a situation would "freeze" the child into a single system action pattern to the detriment of his other bodily systems, and to his total detriment in gaining maximum learning values from the total situation. Lighting should be planned in terms of the minimum quantities of light which will give those qualities of distribution needed for efficient all over functioning in relation to the specific educational tasks to be performed.

3.1.2 Lighting planning is not a problem of bringing the outdoors, indoors, unless the task indoors is similar to the one outdoors--it is a problem of fitting qualities of light and light distribution patterns to the adaptive mechanisms of the eye and body so as to promote effectively, and efficiently, the indoor tasks.

4 The visually-centered skills required in socially defined, visually-centered tasks are learned skills derived from the generalized basic behavior patterns aroused by the organism's efforts to meet its needs in adjusting, or adapting, to various distributions of brightness differences, or contrasts (in the same manner in which other motor skills are learned).

4.1 Because all contrasts within a certain degree arouse action, then the action arousing contrasts in a classroom must be confined to the purposeful forms, or objects, of the visually-centered tasks of the curriculum.

4.2 In all other areas of the visual field the contrasts, or brightness, differences between brightest and darkest areas must be reduced to a minimum just sufficient to define his surround as a three dimensional unit of space. The child's freedom to perform any given task depends upon how well the brightnesses throughout the classroom, providing a background for that task, approach an even distribution, or unity, with the immediate background of the task itself, yet, define the task as part of a three dimensional whole.

4.3 The equipment furnished for performing, or supporting, the visually-centered task must be in keeping with the total behavior patterns aroused by that task so that the performances will not be restrained or altered, and so that dynamic equilibria may be attained.

CO-ORDINATED CLASSROOM LECTURES

Lecture 12

VISION, GROWTH, AND DEVELOPMENT

Visual problems in the classrooms, classroom lighting, and related fields have received probably more attention from investigators than have any of the other factors of the school which might affect the well-being of children. Problems of central vision, visual acuity, accommodation, adequate intensity of light on the working surface, light sources, quality of light, light distribution, and the like have been subjects for repeated investigations, resulting in much information on lighting and its relation to the resolution problems of school children.

Visits to a cross-section of America's schoolrooms, however, show very little of the information gained from these studies put to use to benefit the children in typical schools. Glaring areas; dark corners; too much light on children's faces and not enough on their tasks; harsh shadows and bad contrasts; light-consuming surfaces and finishes; poor posture; unsound visual skills; reading difficulties--all exist in far too many classrooms.

Some investigators believe that many studies made in the past either have not been sufficiently conclusive, or have not been stated in terms practical enough to lead to widespread acceptance and needed classroom changes. These recent investigators feel that, from the viewpoint of school applications, there may be delimiting aspects in the approach to much of the work that has been done. Most research has been concerned with descriptive studies of the eye, problems of visual imagery, and investigations of the intensity of light needed on working surfaces to promote efficient recognition. Many of the studies have attempted to single out the effects on but one organ in the child--the eye--of a single environmental factor--the light on the immediate working surface, or the light in the central and form fields, only--and, in most cases this has been dealt with at only one point in time. These basic studies have revealed facts vitally necessary as foundation steps for later applied investigations. Because of the many ways that organic adaptations can be made, however, and the many elements in any environment or situation that could offset or exaggerate the effects of a single environmental factor on a single organ of the body, studies confined to visual acuity alone, or the effect of improper task lighting on the eye alone, do not furnish sufficient quantitative information to give practical guidance in planning even school lighting programs.

The educator thinks of the child as a totality. He is concerned with the interdependence of the whole child and his total environment. Studies confined to acuity, to task lighting, or to visual fatigue, leave the school man asking, "Should growing children work at maximum acuity?"--"Might there not be other physiological factors offsetting acuity that falls below maximum?" or, "Is the visual fatigue reported by these studies significant, or is it merely transitory, and compensated for by other bodily adjustments?". For school use, visual studies must include answers to these and other questions involving the total child and the ultimate effect on him of any visually adverse factor in his environment.

According to the thinking of recent investigators, insufficient illumination, for instance, might result in a number of different effects on various individual children in any group who may be working in the same classroom situation. These different effects would be based on the individual and specific patterns of behavior, health, growth, and development of each child in the group. With bad lighting in the classroom, one child, because of ways he had found of evading work, might reduce the amount of work he performed, thereby conserving both his energies and his sight. Two children adjusting in this manner, but having different abilities for performing the tasks put before them, might show apparent differences in achievement, if judged by group averages, as is customarily done. The one of low capacity would be considered severely deficient, while the superior child would be judged "average." Another child might feel bound to do everything required of him, but because of lagging growth or visual immaturity, might eventually develop a clinical visual difficulty. The type of visual difficulty developed could, in turn, be dependent upon the particular stresses produced in the child by some certain task he performed, the manner in which he performed that task, or the place in which he worked. Still another child with a superior physique and superior psychological equipment might show no immediate apparent signs of being affected by poor light on his tasks; while another might show merely transitory signs of asthenopia; each determined by the individual time differences in which the children completed the task.

Deficiencies in recognition caused by inadequate illumination might produce later behavior defects in some children if they were required, while under stress, to make full identification of the objects on which they had worked while the light was poor. Then, too, deficient illumination might condition postural or other physical habits of approaching close visual work that could produce visual difficulties at some later date. In turn, because of the interrelation of various systems of the body, a difficulty or defect might be produced, not in vision, but in some other body system that was being subjected to strain when it cooperated with vision in close visual work under improper lighting conditions.

The various school tasks of the child; the specific materials provided for each of these tasks; factors in the classroom such as unbalanced brightness, or restricted seating which might set up actions in the body interfering with the performance of a visual-centered task; the total health status of the child; the growth and health status of the specific bodily systems used in a task; the status of total growth and development of the child; factors in the environment in addition to the one studied, but related to the same bodily functions; and the like, must all be taken into account in any effective study.

For a number of years, both educationists and other scientists have been telling us that the human being is a complex, vital unity. While his various characteristics may be studied separately, as problems of pure research, all are interrelated and interdependent, and in practical application must be considered together, for changes in any one characteristic influence all other characteristics.

Within certain limits, as has been said earlier, the human body is an organic mechanism fitted to survive by its capacity to adjust its relationship to the environment in which it finds itself. It accomplishes this by shifting internal balances between various bodily systems and parts, and by modifying or adapting many of its structures to fit the specific environmental factors which it encounters, and which exist through time. This adjustment of internal balances and modification or adaptation of certain structures (eyes, muscles, bones, body chemistry, etc.) can be beneficial to the individual, or it can be harmful. The harm done, in turn, can be merely a temporary functional change, or it might be a handicapping chronic affliction. Whether the shift of body balances or the adaptations made are good or bad depends largely on the type of forces existing in a specific environment, the degree and duration of those forces, and the body's capacity to "take" them--that is, its capacity to shift its internal economy and modify its related structures in order to balance or utilize those external forces, without depriving itself of energies or structural efficiencies it needs for other uses or adjustments.

Organic life, in other words, consists of a continuous process of balancing activities. Each organ and need of the body tries to meet its particular function or end through striving to establish physical and chemical balances with all the other organs and needs. The body and its parts, in turn, work to establish balances with the forces met in the individual's specific surroundings--such as required tasks, gravity, motion, heat, sound, or light.

Light is one of these environmental forces, and the eyes are sense organs that, when stimulated by light, set up the internal and external balancing activities. As stated in a paper published elsewhere:[1]

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1. D. B. Harmon, "Lighting and Child Development," Illuminating Engineering, April, 1945.

"Visually equipped organisms, including children, do not see to see--they see to act. The problem of lighting is not alone a 'seeing' problem. It is also a problem of establishing proper energy balances between the total light in an environment and the purposeful activities that should be aroused by visual stimuli in that environ, so as not to create adverse body stresses, excessive energy consumption, or deleterious disturbances of motor, biochemical, or other equilibria in the child who is to engage in those purposeful activities. Glare, erratic illumination of the total visual field, and intensities on the working areas insufficient for adequate stimulation of all the necessary responses for efficient action in visually-centered activity, all contribute towards these adverse and deleterious end results."

In another of these papers, I point out that there are at least five bodily activities set into action by light when "seeing" takes place...

(1) The organization of the body for readiness to adjust or to perform in terms of objects or situations in the total visual field which are related to the body's economy (keeping up enough tone or tension in muscles or other parts of the body so necessary actions towards things coming into view can take place quickly).

(2) Aiding the maintenance of the spatial orientation of the body and its balance with the immediate forces in its environment (aiming or centering the body on its various tasks, for example, and holding it there, so that the parts of the body entering into a task can work together smoothly and with a minimum of stress, and so the total task can be performed with the greatest ease).

(3) Adjustment of the eye, head, and total posture of the body to promote efficiently any necessary resolution and efficient reaction towards objects in the field related to the body's economy, (adjusting and holding the eyes, and supporting them in the necessary relations by means of the placement of the head and trunk, so they can function in an optically efficient manner).

(4) Final and efficient resolution of the visual image (this does not mean performance in terms of bench optics; it means efficiency in terms of whatever form or system of optics that has been biologically evolved to meet the needs of the human organism).

(5) Incitation of the visually determined responses that the body's economy requires towards the image resolved and perceived. (Taking the necessary action towards the thing being seen, in order to satisfy the individual's purpose, needs, or interests).

Standard reference works on visual physiology (such as W. Stewart Duke-Elder's Textbook of Ophthalmology, for example) show that there are definite connections between the eyes and the muscles of the neck and trunk and other parts of the body, to carry on these activities reflexly whenever the eye is stimulated by light distributed over the total visual field, or by the immediate light coming to the eye from an object being observed (and which makes it possible to "see" that object). These Static Reflexes (body balancing reflexes set into action by changes in position to offset the pull of gravity) and Stato-Kinetic Reflexes (body balancing reflexes called into action by body movement) play an important part in school vision programs. It is through these reflexes that, in improperly lighted classrooms, for instance, children can be led to consume energy excessively, and adverse stresses can be set up in their bodies which may lead to later damage, even though at any given time the children apparently may be "seeing" the educational materials put before them.

Simply stated, resolution or recognition and identification is a product of enough light reflected to the child's eye from his book or other task to stimulate the eye itself to function properly. The child's freedom to act in relation to his visual task, however, and the efficiency of the various body balances needed to perform and sustain the task economically depends upon the manner that light is distributed throughout his whole visual field.

The deleterious effects of glare on central vision have been well covered in both the illumination and the educational literature. Many investigators have shown how uncontrolled light from windows and other sources, falling on the eye, can veil or wash out the eye's image of the task, if this glare or extraneous light exceeds the amount of purposeful light reflected back to the eye from the task. Central vision can also be interfered with, in a similar manner, by light reflected back to the eye from glossy surfaces, such as varnished desk tops and painted walls and woodwork that have not been treated with low gloss, satin, or matte finishes. Worn blackboards, too, can be a source of such glare. In addition, reflection of adverse light from smooth surfaces can put a haze over what is written on worn blackboards by reducing the contrast between the chalk lines and the blackness of the background. It is practically an axiom of good lighting practice that "there must be more light on the task than on the eye."

The reason for light-colored backgrounds in the visual field, and for low brightness ratios (no sharp contrasts between light and dark areas) in these backgrounds are probably less appreciated by those in charge of school programs. Two physiological processes enter into the performance of visual-centered activities to make these classroom conditions necessary.

The need for lighter room backgrounds (walls, woodwork, furniture, and floors) than are ordinarily found in school rooms is related, among other things, to the adaptation of the eye to various levels of light. As the quantity of light striking the total retina goes down, the body's readiness to perform decreases. Physiological conflicts are set up between the decrease in readiness to perform and the demands for performance made by the visual task placed before the child. In addition, efficient visually-related performance is interfered with by excessive contrasts between task and background. For most efficient vision, the brightness of the total background should be kept just below the brightness of the task.

The need for low brightness ratios in the room (the ratios between the brightnesses of walls, windows, woodwork, furniture, floors, equipment, task, etc.) is related primarily to the body balancing and other visually activated mechanisms. When there is unequal stimulation of the eyes, or of the retinal quadrants, by light (stimulation by brightness contrasts outside the accepted ratios) an effort is set up reflexly within the organism to center the body on the brightest area, or to find a body-centering that will distribute the brightnesses and shadows uniformly or symmetrically over the retina. If the child's attention is required on a task with a different centering, (such as books placed on the surface of a desk, while a window of greater brightness and a blackboard of less brightness are in his field of vision) the reflex effort to come to a body balance with the background has to be counterbalanced or offset by additional effort to hold the body's centering and attention on the task. Energy-wasting stresses are set up, or the child alters his relationship with the task in a manner outside his tolerances for efficiently performing that visually-centered activity. The greater the number of bright and dark areas, the greater the number of physical conflicts set up in the child in his physical and psychological efforts to establish a balance between his environment and his work. Stresses thereby become greater, and they may become damaging strains. If the child is to perform his visually-centered school tasks freely and efficiently, without useless expenditure of his limited energies, and without threat of strain, malconditioning, or organic damage, then, the light coming into his classroom must be distributed as uniformly as possible throughout his total surroundings, and it must appear in his total visual field as brightnesses well inside those ratios his body can tolerate.

"The child at birth is neither complete in size nor in the structure of each of his bodily systems that will eventually work together in making him a coordinated and integrated functioning human machine. The primary task of every child is to grow--to increase in dimension and proportion towards his inherent adult size, and to complete his bodily systems and structures through which he can gain mastery over himself and his surroundings.

"'Growing up' is the progress of the organic child towards a physically mature state. It is the filling in and completion of those sensory, nervous, bony, muscular, and visceral structures which are only germinal or partially complete at birth, and for which nature needs the years of infancy, childhood, and adolescence to change these initially simple or rudimentary forms to the final complex and efficiently functioning patterns that should exist in an adult."[2]

Those who have been studying intensively the way children grow and develop, as has been repeatedly said in these lectures, have demonstrated in a number of forms that the full development of a child's potentialities can come only through function. While the initial growth of the body structures with which he will perform is instigated and controlled by the particular patterns inherent in him, the exact form acquired, and the amount of growth achieved depends upon the use to which those structures are put. However, if these forms and quantities of growth, within their possible limits, are to result in an efficiently operating total individual, who can carry on without risk of damaging stress or strain, then during the growth of these various bodily structures, the functioning demanded of them must be appropriate to the growth they have achieved at any time, must have relationship to the growth patterns, must be consistent with the patternings of basic behaviors, and must meet the needs and resources of the child as a whole.

Because virtually all of the educational tasks of children are either introduced or carried on through critical vision, involving the balancing mechanisms described above, two factors in the growth processes must be taken into serious account in planning or arranging the visually-centered activities of the classroom.

The child has just so much energy to expend, depending upon the nutrients he has taken in. This energy must go towards satisfying his basic needs in staying alive (respiration, circulation, muscle tone, etc.); converting his raw foods into usable chemical forms (digestion and storage); protecting him against infection and other disease threats; growing, and furnishing the energy for all the activities and adjustments demanded by his environment. Only a limited amount of his energies is really free for activity. When environmental demands exceed the energy free and available for meeting them, the environmental demand is met by depriving some other vital need of its energy. Growth suffers first in most cases, for "activity takes precedence over growth in the use of nutrients." Continued stresses induced by poor distribution of light, by bad contrasts, by glare, or other lighting and decoration factors not in accord with good practice, or by visual performance demands inconsistent with basic visual performance patterns, might readily use energy needed for growth, for body function, for protection against infection, or for overcoming other adverse and recognized factors in a child's surroundings.

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[2] ibid.

Bodily growth is inherently a balanced bisymmetric process. A study of the gradient growth shows that its geometric centers, at any given time, are always at the center of the greatest bodily activity. In the child who is growing and developing normally, the centers of activity induced by the environment should always be the same as those centers that are laid down by his innate balanced growth patterns. If the centering of environmentally induced activity is different from the centers for completing normal growth patterns, there will be a structural conflict between the unbalanced growth taking place around the new center of activity set up by the environment, and the balanced growth taking place at the natural center. Such shifts in growth can produce unbalanced developments that lead to later operational conflicts, distortions of sensation or performance, or actual body breakdown. In other words, the child's body, or bodily systems, grows along the lines of stress induced in it by various activities, in order to reduce those stresses. If the lighting or visual environment sets up centers or lines of body or systemic stress that are not normal, and do not fit the alignment of inherent and normal growth forms and normal body mechanics, the result is structural warping. As the child continues to grow and function in such surroundings, the final result is asymmetrical or unbalanced body structures, deviating performances, or physical or psychological lesions and disabilities.

Body stress and bad posture, due to disturbances of the child's body mechanics by improper or inadequate lighting, or by poor seating equipment, or by physiologically unsound teaching method in close visually-centered tasks, could also interfere with the success of his educational performances and his learnings. The place of continued tension in the production of behavior problems is familiar to every educator who has studied the mental hygiene of the school child. It is just as possible for continued body stresses and tensions to produce asocial and avoidant behaviors, as such behaviors can be produced by persistent tensions set up through psychological or social factors.

Body stress might also interfere with subject matter learnings. For example, as was said earlier, a young child, at least in a large measure, reproduces exactly what he senses, and learns exactly what he reproduces. This is merely another way of saying the child learns through activity.

If an individual child is suffering from sensory, motor, or other bodily defects, or if his environment is such that he is inadequately or improperly stimulated, or if it restrains him from fully sensing or performing, then his learnings will be distorted to the degree his sensation or performance is distorted by those defects or limitations.

Finally, with adaptation having as its basis the alteration of structure by function, the malfunctioning due to continued stress and faulty visual and body mechanics would eventually maladapt structure, leading to continued visual malfunction, if not clinical organic eye and other related lesion.

Light is something more than a means for aiding the child in the recognition of words and objects. It is a force in his environment, and an important one; a force that can shape or distort functioning and structure of the total child--his eyes, his muscles, his learnings, his well-being--currently, or permanently.

Single measurements within the realm of physical optics or the physics of light, such as measurements of intensity correlated with the refractive eye defects observed in a group of children at some given time, tell little more than whether there is an apparent relationship. Such evidence of the need for good lighting may not be sufficiently convincing to those who know the complexity of human beings and how many factors can exist beyond control, that could distort the results of such an investigation.

A little more can be gained by relating the dynamic factors of light distribution, to similar factors of physiological optics found in a given school situation. The extensive serious work that has been done on the relation of the various aspects of lighting to efficient eye functioning falls in this class.

Studies which are integrations, however, of all the dynamic factors of visually-centered activity with the processes of structural completion of various parts of the child's body; with the limits of organic tolerance, and the demands of school tasks; with the intersystemic relationships and stresses of the total organism, and the conflicting or complementing factors in the environment affecting the child, can go much farther in furnishing that insight into visual problems of the school child which school men and vision specialists should have for planning the visual-centered activities, and the adequate visual environment that must exist in schools.

Lecture 13

VISION AS A DYNAMIC PROCESS

Part One

Vision is proving to be the dominant function in all the actions of the organism in relation to its space world, from the simplest to the highest and most complex. In connection with the three fields enumerated by Gesell, mentioned earlier, which give substance to "visual image," visual processes enter into localizing the organism in space; adjusting the organism in efficient relationship with that which it wants or needs to manipulate; holding the organism in support; identifying significant factors or symbols in the surround; synthesizing and unifying other sensations and experiences with the immediately visual ones to derive meaning; directing actions; and, establishing needed and satisfying equilibria. From organic survival to social demands, no one of these visually-related processes can receive emphasis to the exclusion of others if the organism is to function efficiently.

In the previous papers, stress was placed upon the position equilibria, both static and dynamic, and frames of reference occupied in the organism's relations with its space world. Before leaving the subjects of equilibria and frames of reference, some additional matters should be included, germane to our purposes here.

A good deal of thinking on vision has been influenced by some older or outmoded concepts of learning. Two of these are of particular interest for the moment. The first of these assumed that learning was a process of passive absorption--a pouring-in process--with the learner sitting like an empty receptacle waiting to be filled with facts (socially-defined), his behavior changing automatically as he was presented with those facts either in concrete or symbolic form. Little need be said here in refutation of this concept. Education has long since demonstrated (in theory, at least, if not in all the practices of the school) that a child grows, develops, and learns through action. In fact, all ages learn through doing and experiencing: (a) concrete actions and experiences before symbolization; (b) actions in response to symbols, and (c) actions after symbolic experience. However, preoccupation with capacity to recognize detail (especially the detail in certain kinds of symbols), with little interest in the related action factors, has been a residual of the earlier passive concept of learning in the work of many of those studying or concerned with visual functions.

The second concept has to do with learned reactions and learning of motor skills. This concept in the elaboration presented throughout these papers is recent. It has not, as yet, greatly permeated the thinking of those in education, although it is more consistent with neurophysiology than previous assumptions in this field of learning.

Previous concepts of learned reactions and the development of motor skills have assumed that these reactions and skills are learned through repeated use of a specific group of muscles, with unneeded muscles dropping out of the group with repetition of the action as a result of the law of economy of effort, until an acceptable action is acquired, or until the limit of capacity of the individual is reached. This concept, in effect, assumes a physiological dualism in which the sensory mechanisms set up a perception of the task to be done as a model or standard, and then specific motor equipment is put into action to reproduce that standard. The learned reaction or motor skill is actually showing itself to be, not simplification of operation through training of a specific group of muscles, but spatial direction of movement in relation to a frame or frames of reference. It is an adaptive pattern in which action is a sequence of statistically determined movements directed, (a) in relation to the axes of the body, (b) in relation to the spatial coordinates of the organism's orientation to itself and to its environment, or, (c) in relation to all these. Direction is determined by the organism's translation or transformation of the systems of coordinates of its perceptual space world into its experientially determined systems of coordinates of itself. What is learned is direction and location in relation to a set or sets of coordinates and transformation groups. Whether the coordinates used to determine direction of movement are "real" or not, depends upon the adequacy of the organism's experiences.

Lashley,[1] who suggested a similar concept of learned reaction, said: "The transition from the visual perceptual to the motor level thus appears to be, primitively, the translation of one system of space coordinates into another. Direction is dominant in visual memory and the reaction reduces to a sequence of directed movements. Intervening between these is the system which constitutes spatial and postural orientation...

"The visual system is primarily concerned with spatial orientation and for it the transition from a sensory to a motor pattern can be most adequately conceived as an interplay of polarized systems or of interweaving dynamic patterns in which the spatial properties of the visual stimulus are translated by integration at a series of levels into modification of the general pattern of postural organization."

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[1] K. S. Lashley, "The Problem of Cerebral Organization in Vision," Biological Abstracts, Volume VII, Visual Mechanisms, Heinrich Kluver, Ed., The Jaques Cattell Press, 1942.

From the above concept of learned reactions it can be readily seen that the visual processes of major significance in learning and development (and in any performance) are those entering into describing[2] the frames of reference of the space world and the organism's orientation to that world. Of necessity, then, the dominant processes basic to adequate visual perception are the "dynamic" ones of those visual mechanisms, the operations of which, when unified with similar aspects of other modalities, would enter into describing direction[2] and location, in three dimensional space, from and in relation to the organism.[3]

The concomitant visual mechanisms entering into defining or resolving detail are the "static," or "recording" portions of the perceptual processes. The neural results of the function of these mechanisms, when unified with the resultants of similar function of the other modalities, provide the bases or limits for the descriptions mentioned in the preceding paragraph.

The place that feeling or feeling tone occupies in laying the foundation for individual meaning of experience has already been implied in an earlier discussion of autonomic activity. All sense data in relation to any specific surround are integrated, synthesized, or unified in the higher processes as part of their function of deriving the meaning to the individual of those aspects of the surround having, or apparently having, significance to his total economy. The affective data of feeling tone represent the adjustment in the visceral field that he makes or must make in meeting the demands of the stimuli of an environment. In effect, these data are the organism's "profit or loss" accounts or estimates in relation to specific stress or action.

Recent neurophysiological studies indicate that cortical function apparently includes:[4] (a) collection and storage of perceptual and sensorimotor data resulting from both external and internal stimulation; (b) summation, integration, synthesis, unification, abstraction, and symbolization of the organism's experiences; and, (c) organization, direction, inhibition, reorganization and redirection of total behavior as a result of (a) and (b).

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[2] These and similar terms are used here in the mathematical, mechanical, or operational sense only; i.e., "describe," To draw the figure of, outline, delineate; "direction," The trend of a line or course of motion, as determined by its parallelism or deviation from parallelism with some line assumed as a standard; "limit," The first and last value of a series of values; etc.

[3] To some extent magnitude might also be described through these operations.

The adequacy and the validity of the above parts of cortical function must rest largely in the adequacy of function in the fields of skeletal and visceral actions, for it is from these actions that are derived the data used in the cortical functions enumerated. Adequacy in these uses must meet, simultaneously, a number of tests. Do the expressions of function, and the processes involved, preserve and promote the integrity of the organism through space and time? Do these expressions and processes approach an optimum for the organism? Are the adjustments made by the individual, and the meanings he derives from experience, in keeping with what is known of reality? And, does all this direct him towards being a satisfactory, contributing, and satisfied member of the social group?

The organization, inhibition, or direction of behavior in a cultural surround is successful only insofar as it meets the group's needs, deals in the group's symbols, and implies the group's syntheses and abstractions. In making these demands, the group and its responsible members must constantly bear in mind that insight into these needs, symbols, and abstractions, and the necessity for compliance, is not native to the organism, nor is insight into reality or into the best forms of the adjustments the organism must make to meet its continued needs. The only things inherent in the organism are potentialities for acquiring these insights. As was said earlier, to produce these insights, there must be deliberate provision of developmental experiences for the organism which at one and the same time must meet biological needs, physiological wants, and social demands.

Society's preoccupation with communication of those experiences which contribute either to society's promotion or to preservation of the integrity of its structures--especially when this communication demands the level of symbolization required in a complex social order--leads to practice of a partial dichotomy by emphasizing a direct approach to the apparent needed higher or cortical functions through the immediately auxiliary anatomical structures seemingly involved (eyes and "visual" centers of the brain), to the exclusion of the necessary skeletal and visceral functions.

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4. This list is not intended to be complete or definitive.

Emphasis on communication through symbols has led those working with "seeing" (and also those working with lighting) to be almost wholly concerned with a partial and very limited function of vision: the mechanical resolution of detail with its physiologic and anatomic correlates of accommodation and acuity. Such a concern devalues unwarrantedly the related and inseparable visual processes listed above. All of these processes are significant concomitant and associated factors in Gesell's three basic fields (skeletal, visceral, and cortical), in which the child (and the adult as well) "seeks," "holds," "discriminates," "defines," "unifies," and "interprets" the "visual image." Without these processes accommodation and acuity, in relation to the performance of a specific, sustained, visually-centered task, could not exist.

Primary concern with accommodation, acuity, and efficient resolution of the details of symbols, has led to the erroneous interpretation of "visual image" as the optical distribution of the energy of stimulation over the central area of the retina.[5] In turn, this interpretation has led workers in lighting and vision into a number of faulty assumptions as bases for their research and practice. Among these faulty assumptions are the six which follow:

(1) There is a one-to-one relationship between the optical distribution of the energy of stimulation on the central retinal patch and the performance elicited: The efficiency of this distribution, it must be admitted, is one of the many determinants of the performance at some time, either in the developmental sequence of the concept involved, or in the immediate sequence or group of functions that make for the performance. Its place in these, however, is limited and transitory. Performance is the adjustment of the total organism to all the factors in the surround in terms of past experience, concepts established, concepts emerging from the immediate experience, current needs of the organism, and, the current distribution of forces. Evidence is accumulating which indicates that a forcing of the details of the communicative symbol, either through lighting or other means, can interfere with the other functions related to performance, or, it can direct the processes of the organism towards responding to the physical details of the symbol and not to the concept for which it stands.

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[5] Even this optical distribution is too often erroneously defined, when it is thought of, in terms of the findings of bench optics.

(2) Concern with "vision" can be limited to attention to the functioning of the sensory mechanism of sight (or part of that mechanism) alone, to the exclusion of associated processes; and,

(3) Visual problems are all products of defects in the anatomical efficiency of the eye, the extraocular musculature, the ocular adnexa, or the afferent neural pathways of sight, and the associated assumption that, visual structures are non-adaptive.

The Mechanisms of vision, like other mechanisms having to do with the promotion of rapport between the organism and its environment, is structured to gather, record, preserve, organize, unify, transmit, and use information. While a large part of the function of the visual mechanisms are related to the organization and communication of information, use of the information is also a part of that function. In spite of the diversity of expression of a function which is possible in the human organism, the complete system of receptors, afferent conductors, adjustors, efferent conductors, and effector apparatus (and supporting structure, and related structure and function) must all be taken into account in evaluating the structure or efficiency of any mechanism. This sensorimotor relationship is recognized to a limited degree when the efficiency of the extraocular musculature is considered with the efficiency of the eye itself. The reflex movement of fixation, however, is not the only action patterns related to visual stimulation.[6] Head and body posturing movements,[7] and actions involved in performing the purposeful task are all part of the sensorimotor organization of vision.

The visual mechanism, being largely a communicative mechanism (and our dominant one), does give us concern with the accuracy of the information it communicates for use. However, we cannot be preoccupied with the apparatus for receiving this information, nor the apparatus for adjusting these receptors, because, to borrow the terminology of the communications engineer, neglect of the other visual factors can lead to "noise." Wiener[8] tells us that "the information carried by a precise message in the absence of noise[9] is infinite. In the presence of noise, this amount of information is finite, and it approaches zero very rapidly as the noise increases in intensity."

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[6] Reflex movements of fixation primarily function to center the organism on the distribution pattern of light. They can also be directed to function to center the organism on a socially-compulsive task, many times to the detriment of the organism when both functionings are required by the surround because light-centering and task-centering differ.

[7] For example, Duke-Elder says: "Just as the labyrinth dominates the proprioceptive system, so the eyes tend to dominate the labyrinth... there is an intimate association between movements of the eyes and changes of posture, and a close functional reflex correlation exists between the extraocular muscles and the labyrinths which record the movements of the head in space, and the muscles of the neck which register movements of the head with respect to the trunk." Sir W. Duke-Elder, Text-Book of Ophthalmology, Vol. 1, p. 624.

The anatomical efficiency of the sensory structures does make for a portion of the efficiency of function of the visual mechanisms. However, in an adaptive organism, each part of a sensorimotor system is a function of every other part, and the functioning and structural status of any part is affected by and adapting to the functioning and structural status of every other part. In addition, the functioning or structural status of the parts of any system are affected by the functioning or structural status of related systems.

If an adaptive sequence through time and repeated stress (as distinguished from immediate adjustment to a situation) was to be loosely indicated, it would probably take somewhat the following order. First would come change of function due to change in neural organization or efficiency (from a. immediate total needs of organism, to b. conditioning, to c. learning); then would come biochemical change, followed or accompanied by change of structure in musculature; next, the tissues acted upon; and, finally, supporting structure. Duke-Elder[10] comments on one visual aspect of this in a constructive, but limited way when he says, "The process by which the faculty of binocular perception is acquired, like that of all other habits, is a facilitation of the reflex paths, such as is exemplified in the conditioned reflexes of Pavlov. It is thus built upon an already existing basis by education, a circumstance which accounts for the varying degrees to which fusion...may be developed in different individuals." Conditioning, it should also be remembered, is not necessarily constructive. It is adaptation to the factors of the immediate surround or task, hence, the functioning it produces could be adverse in other surrounds or tasks. In addition, what is little recognized is that the biological principle that "structure alters function" also has its converse which is equally true, "function alters structure." Julian Huxley stressed the importance of the latter when he said:

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[8] Norbert Wiener, Cybernetics, John Wiley and Sons, New York, 1948.

[9] "Noise," in this sense, can be defined as random agitation of a conductor which limits, "blurs," or, in any manner interferes with the impulses the conductor should be transmitting--"static." In this connection, "noise" could be represented by incompatibility of the visual sensations of a factor in the surround with sensations of that same factor through other modalities; conflicting use of common pathways or musculature in satisfying both visual and other need; proprioceptive or feedback impulses from adjustive actions other than visual to motor equipment being used in visual processes, etc.

[10] op. cit., pp. 1055-56

> "Most biologists do not seem to realize the extent to which functional modification occurs in the normal vertebrate body. It appears to be true, not only that the size of every muscle in the body depends upon function, but the size, directions and structure of every tendon and bone; the detailed configuration of the blood-system depends largely, or perhaps wholly, on hydrodynamic considerations; the size of every gland is regulated by its function; and even the nervous system does not escape. It is only in earliest development that structure precedes function; later, structure is the resultant of function."

Finally, the eye, like all other structures of the body, does not reach capacity for optimum function merely by structural completion through growth. Growth alone leads structures to capacities for minimum function only, because the only demands of structural completion are generalized behaviors, not specific ones. Optimum function comes only through constructive use, whether that function is "visual acuity" or purposeful direction of movement.[11]

(4) Accommodation takes precedence in the sequential functioning of the mechanisms of the eye, setting into automatic action the remaining mechanisms.

While each of the mechanisms of "seeing" is largely the function of the others, there is growing evidence that accommodation takes precedence only in momentary visual tasks, and then primarily when the human organism's need for equilibria are being satisfied through activities initiated other than by immediate visual stimuli. Such precedence of accommodation would apply in cursory visual inspections, "shopping," many visual "testing" situations, some pursuit movements, and the like.

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[11] Among others, Marshall and Talbot imply this in their discussion of "dynamic acuity" in connection with their paper, "Recent Evidence of Neural Mechanisms in Vision Leading to a General Theory of Sensory Acuity," Biological Symposis, Vol. VII, Visional Mechanisms, Jacques Cattell Press, 1942.

However, when a close visually-centered task is sustained, such as in school tasks, in drafting and accounting rooms, etc., the first functions of vision are opticokinetic and body-balancing, localization and centering on the task. Accommodation follows these, not as a function of the detail of the task, but as a feedback function of establishing the eye and body balances needed to center on the task, and establishing the necessary frames of reference for direction of performance. In fact, these centering and balancing functions would seem to have their sensory origin, not even in central areas of the retina, but in the periphery.

(5) A seeing task can be defined as a two-dimensional task, or working on a plane.

The very existence of a three-dimensional organism in three-dimensional space, organizing its actions in terms of direction of movement within three-dimensional frames of reference, precludes such an assumption. The organism operates around a plane--not on it. The definition of "plane" tasks, such as reading, writing, etc., without landmarks of reference such as placement in the individual's space world, texture, and the like, and without provision for full freedom of performance in relation to the visual and all other stimuli, can be nothing but destructive to the ends sought in the visually-centered task.

(6) A single function, or the function of a single part, is maintained as a constant throughout the total process; and, visual function is identical throughout all aspects of the space, time, and experience related to the task.

As has been said, the definition and resolution of detail are the "static" portions of the perceptual processes. As such the mechanisms concerned with these aspects of operation are confined to defining limits and consequently do not or cannot continue in a constant state throughout the total performance. Throughout performance accommodation would be expected to change, within certain tolerances, as the symbols and concepts being dealt with redintegrated the various significant frames of reference from which they were derived, or organized the various frames of reference into which the individual projected himself in imagination.

This paper has not been intended to be an exhaustive discussion of all the points raised; these will be developed later. Nor has it been intended to disparage the place that accommodation and acuity occupy in the visual processes. Its purpose has been to stress the inseparability of all the higher and lower functions in the performance of that widely adaptive organism, man, as he organizes his space world in terms of reality, and clearly defines his place in that world. To single out for attention a single portion of the complex of processes that make up those functions, or, to oversimplify in provision and planning for man's visual experiences that lead him to an adequate definition of his space world is to do nothing, in the long run, but make him a danger to himself, and a detriment to society.

Lecture 15

VISION AND LIGHTING[1]

Part One

In a previous lecture, our discussion pointed out that society's major concern with "higher" functions in man tends to lead those planning the tasks, developmental experiences, and artificial surround of both children and adults to oversimplify, in their thinking, the processes involved in human function in relation to those tasks and surrounds--the very processes which give validity to society's required actions. This oversimplification in thinking and planning takes place to the potential detriment of both the organism and the socially-efficient performance of its tasks. This is particularly true in planning lighting for vision.

In the December, 1941, issue of Illuminating Engineering were two papers that summarize some of the principles of lighting expressed by illuminating engineers. One of these papers was "Comfortable Lighting" by Ward Harrison and Matthew Luckiesh, and the other was "The Anatomy of Visual Efficiency" by H. L. Logan.

Very roughly stated, Logan's paper is partly concerned with eliminating, as direct responsibilities of the lighting engineer, considerations of ocular discomfort and ocular fatigue, and restating the engineer's function as that of providing conditions favorable to efficient vision.

He relegates to the province of the physician what he labels as "non-optical causes of discomfort under lighting conditions," and lists as some of these causes--headaches, (stating that there is no medical proof that ordinary lighting conditions cause headaches); general fatigue; general weakness from, among other things, vitamin deficiencies; certain dietary factors, principally the photosensitizers; anoxia; muscular and articular defects inducing fatigue; color; and, uncorrected, or improperly corrected eyes.

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[1] Adapted in part from a paper, "Lighting and the Eye," presented by the writer at the Second War Lighting Conference, Southwest Region, Illuminating Engineering Society, Dallas, Texas, April 25, 1944, and published in Illuminating Engineering, Vol. XXXIX, No. 8, September, 1944.

Logan goes on to state that some "peripheral glare"[2] is necessary for optimum visual acuity, and demonstrates the need for illuminating the total field of vision for efficient seeing, doing it according to certain laws which he derived statistically for the distribution of light throughout that field.

Harrison and Luckiesh, in their paper on "Comfortable Lighting," state effectively certain objectives of the illuminating engineer. They say his function is to obtain: (1) Maximum visibility of the objects to be seen, or of the visual tasks to be performed; and, (2) Maximum comfort[3] of the observer at all times, and more broadly, maximum ease of seeing when critical seeing is being done.

After commenting on direct and specular glare in nature, they go on to say--"one conclusion which we may properly reach from studies of natural and apparent comfortable lighting outdoors is that we find lighting pleasant and comfortable when there are more footcandles on the seeing task than there are incident to the eyes." They also state that, "artificial lighting for comfort cannot be achieved if brightness contrasts are too great either due to the character of the lighting system or to an inordinate range of reflection factors."

No one can quarrel with the functions of the illuminating engineer, or the principles of illumination set forth in either of these papers--as far as they go. Some questions do come to mind, however, if the lighting engineer's task is limited only to providing conditions for efficient vision, and he means by vision, only the eye task of critical resolution of detail.

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[2] "Glare" is not a proper term in this connection. This conclusion, with the supporting data, is an unconscious recognition of the fact that oculomotor and optico-kinetic functions are principally set into action by peripheral stimulation, and, in a sustained task, accommodation is largely a function of these centering and balancing actions--(i. e., "Accommodation is a function of convergence") and is not independently initiated.

[3] "Comfort" is not an adequate criterion of efficiency or well-being. A feeling of "comfort" can be induced through transitory states of optimum efficiency in performing the task; through partial or complete inhibitions of task performance; and, through adaptations which conform structure to the stress-producing factors of a specific situation. Euphoric states can also be induced by suggestion, by motivation factors, and by pathological processes.

I am concerned about tomorrow's efficient seeing, and the physiologic end-results of optically induced performance if the illuminating engineer stops with just these broad generalizations in planning for future lighting. I am concerned, not because of any error inherent in these generalizations, but because of certain implications in the ways they have been derived, and, as a consequence, the interpretations illuminating engineers seem to place upon them. I do not think these bases for the derivations and the interpretations go far enough, by any means.

Most of the data and interpretations currently made seem to rest upon at least four things:

(1) Observations and physical measurements made of "seeing" in terms of outdoor conditions, or tasks.

(2) Efforts made to reproduce the characteristics of daylight indoors.

(3) Statistically determined criteria based upon too limited areas of measurement of the total organic functioning involved in relation to quantities and qualities of light, and various distributions of those over the fields of vision, i. e. --momentary acuities rather than sustained acuities; accommodations for a single distance under a given light, rather than all the accommodations that will be required under that light; the sequence of accommodation--convergence relationship in the task to be performed; only the physical, or physiologic optics in a situation, rather than those plus the related biophysics and biochemistry; immediate observable overt performances, rather than these and all the covert activities plus the final biologic end-result, etc.

(4) Delimitation of data to only that related to "seeing" as resolution of detail, and immediate visual-centered performance efficiencies judged by socially determined criteria, rather than a study of lighting in relation to the total physiologic economy of human beings related to ocular stimulated activity.

(5) Etc.

First of all, I seriously question whether conclusions drawn from outdoor seeing conditions are wholly valid for setting up standards for indoor visual tasks, and I am inclined to believe there is enough physiological evidence to indicate that not only the physiological optics, but the total physiology in the seeing task defines the standards for its illumination.

Second, I would like to raise the question as to whether reproduction of the characteristics of daylight for illuminating certain tasks of close indoor vision might not, in many instances, be detrimental.

Third, I question whether statistical criteria, derived only from observations of immediate overt behavior, or from the clinical physiology of the eye alone, such as formulas for the "improvement of reading speed and comprehension," "rate of involuntary blinking" criteria, curves of "the relation of acuity to light intensity," and the like, are wholly adequate for determining total ease of "seeing," or the effectiveness of the total visually related performance.

Many workers in the field of lighting and seeing like to philosophize about the millions of years of the evolution of the eye in outdoor seeing tasks with the consequent perfect adaptation of the eye to outdoor light, and the need to approach outdoor standards in providing lighting for all seeing situations. Let's philosophize with them a bit, for philosophizing is a legitimate tool of research, providing it is logically done.

With no intention of being teleological, let me ask a question: What was the biological purpose in the eye evolving to fit outdoor conditions?

Like all sense organs, the eyes are specialized structures of the body--the "trigger" portions of special systems--developed; (a) to keep the body organized and ready to react to, (b) and then in rapport with, and adjusting for, environmental factors that threaten, or give promise of promoting the survival of the total organism. This includes the organism's adjustments to forces in nature, such as gravity; its adjustments to changes in its relationships with those forces, such as its movement through space; its identification of factors in its total environment as threats, or promises concerning its well-being, such as visual resolution and perception of objects of situations; its performances in relation to those factors, such as grasping or withdrawing; and, its readiness or preparedness to do all these things efficiently, such as muscle tonus, the "readiness" position of movable sense organs in relation to the area of possible sources of threats or advantages, etc.

With these and similar functions in mind, it does not take any profound research in neurology, or physiology to establish that there are, for expediting all these functions, actual bodily mechanisms to provide physical connections between each type of sense organ and the appropriate motor organs needed for reacting to those environmental forces and factors to which that type of sense organ is sensitized. Witness the various connections of the VIIIth nerve system which relate the retina, the extraocular muscles of eye, the balancing sense organs of the labyrinth of the ear, and the muscles of the neck and trunk, so that the body can adjust its balance, (a) to gravity, (b) to gravity and the mechanics of its activities in space; and, (c) to gravity, activity in space, and its best spatial orientation for full and adequate sensory identification.

The social function of seeing for identification only (such as the acquisition of knowledge through reading) is just a cultural use of but one of the total pattern of activities, or processes, aroused when the eye is stimulated by light. We are prone, because of our cultural point of view, to think of this process as being independent of all the other processes set into action by the eye, but, when light stimulates the eye, all of these processes go on, in spite of our cultural emphasis on the use of only one of them.[4]

What were the forces acting on primitive man that determined his eye-related adaptations in order to survive? He was a bilaterally developed organism capable of moving freely through outdoor space, so his line of sight evolved forward and downward to orient him to his surroundings, and bring his body into balance with forward movement and with gravity. It was necessary for him to be on the alert for threats, and for promises of food and shelter, so, within the limits of adjacent body structures, his eyes evolved so that he was on the alert peripherally for movement and form while his eyes were in "readiness" for needed change at a point where he could most economically resolve the widest possible forward field. (Our 6 meter point used for acuity measurements.)[5]

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4. Promoting high recognition values through arbitrary increases of lighting values may, because of all the physiologic functions related to light, also promote high readiness values for the fundamental evolved biologic patterns of performing. These are primarily spatial adjustments of relationships to all the environment which surrounds the subject in order to satisfy his aroused organic needs.

   Merely raising intensities without reference to light qualities, then, in order to enhance recognition for someone working at a confining task where that confinement could defeat the satisfaction of the biologic need for spatial adjustments that had been simultaneously aroused, could result only in ultimate fatigue, or physiological and psychological conflict. This could be true even if statistics showed that production efficiency in a socially defined task went up with the heightening of recognition values.

5. This point should be thought of, not as a rest point, but as a point of equilibrium of "readiness" between visual actions defining spatial factors "towards" the individual and those defining such factors "away" from the individual.

While in readiness on this point, it was necessary for his eyes to evolve so that minimal stimulation in the peripheral areas kept him organized for immediate action towards any factor coming into those areas that threatened him, or could satisfy his needs. Because complete resolution for identification involved satisfying optical laws through a binocular structure, evolution necessitated the establishment of motor mechanisms mediated by light and vision to put the eyes, head, and trunk into spatial relationships with environmental factors for adequate resolution with a minimum disturbance of other bodily needs and equilibria. Because the eyes were evolving as light-sensitized sense organs, light energy was needed to set into action all these mechanisms, and the available light was outdoor light with its high energy values principally in area of blue-greens, greens, and yellow-greens, and the reflected light from a chlorophyll dominated environ with its predominant colors around green. It seems only natural, then, that the evolution and adaptation of the eye for the survival functions set forth above should be in terms of these spectral-energy qualities of light inciting, or mediating, at least the readiness for those functions, as an examination of the data on peripheral retinal sensitivity, the possible area and thresholds of the retina stimulating the posturing mechanisms of the eye and the body for sight, and the like, apparently indicates they are.[6]

Outdoor adaptation then, seems to be for a man moving through space without cultural restraint, confined to no close sustained visually-centered activity, with only relative momentary adjustments of resolution away from the "readiness" positions of the eyes, and the primary readiness for all this probably sustained by the principal spectral-energy characteristics of outdoor light.

The answer to our philosophers is "Yes, man's sight has adapted through years of evolution to outdoor light, but in terms of outdoor seeing tasks."[7]

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6. For which, see some of the implications in the data presented in various papers in Biological Symposia, Volume VII, "Visual Mechanisms," Heinrich Kluver, Ed., Cattell Press, 1942; various studies in electroencephalography; various studies of absorption spectra of certain essential nutrients, etc.

7. It might be pointed out here that these tasks were performed without the sustained restraints of the mechanical, or cultural surroundings of a job. So, Early Man's freedom to move and adjust, and this forward and downward line of sight also evolved some protective postures and structures for his eye to prevent its damage from any deleterious qualities in his only light source, as long as he was free from civilization's restraints of sustained close tasks and from fixtures and lighting which defeat these protective posturing adjustments.

The problem of lighting a modern indoor environment is not merely a problem of how to make seeing per se more comfortable, or more speedy, or more accurate--that is at best only a minor part of the job. Organisms, including man, do not see to see--they see to act, and the problem of good lighting is linked with the efficient performance of every visually stimulated act just as closely as the sense organs of sight are physically, or chemically linked to the posturing and motor organs of spatial orientation, manual manipulation, and body tonus and balance. The real problem of lighting is the problem of fitting light of various kinds into man's civilized environments in such a way that he can perform his culture-made tasks in not only a socially satisfactory way, but, more important, in a biologically efficient manner in keeping with the way all his light-related structures have evolved. It is not a question alone of, "Is this light adequate to resolve?", but, "Is this light an adequate stimulus for all the body mechanics and chemistry entering into this given task?", and, "Can the subject fully resolve, with a minimum of effort, the object to be seen at a point where he can manipulate it in a manner in keeping with good physiology, while satisfying all his organic needs affected by light?"

I am doubtful as to whether these questions can be fully answered through reproducing light having all of the characteristics of daylight with the necessarily concomitant incitation of all the bodily organizations for doing the outdoor tasks for which man evolved.

The physiological functions of light in any seeing task can be summarized much in the following order: (1) The organization of the body for readiness to adjust, or to perform in terms of objects, or situations in the total visual field which are related to the body's economy; (2) Aiding the maintenance of the spatial orientation of the body and its balance with the immediate forces in its environment; (3) Adjustment of eye, head, and total posture of the body to promote efficient resolution and efficient reaction towards objects in the field related to the body's economy; (4) Final and efficient resolution of the visual image; and, (5) Incitation of the visually determined responses the body's economy requires toward the image resolved and perceived.

Lighting is not a problem of bringing the outdoors, indoors, unless the task indoors is similar to the one outdoors--it is a problem of fitting various qualities of light to the adaptations of the eye and body to promote effectively, and efficiently, the indoor task.

The illuminating engineer, logically, has spent the earlier years of the development of his profession mastering the physical data concerning his tool, light, and acquiring the basic skills needed for its manipulation.

Now, he must determine more adequately the human limits of the applications to which his tool can be put, in order to use it successfully in promoting society's advancement.

The physiologic functions of light can be met only through studying the total physiologic economy involved within the limits of the structures man has evolved, and then relating the findings to any task he may be required to perform that starts with visual stimulation. With this background, the engineer must then provide a light of such qualities for any given task as will activate the successful performance of that task, while promoting the doer's physiologic economy, and preserving the integrity of his structures.

To promote efficient vision, the illuminating engineer must be concerned with more than quantities of light and distribution of these quantities: (1) He must be concerned with qualities for given tasks based on sound visual physiology for that task, (2) He must know the total physiological effect of the light media with which he is working; and, (3) He must plan for today's efficient seeing in terms of tomorrow's ocular efficiency as well.

He must be, not a mathematical manipulator of the physical media for producing light, but a human engineer in the field of visually-centered activity.

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"VISION, GROWTH, AND DEVELOPMENT"

by

Darell Boyd Harmon

AN OUTLINE FOR FURTHER STUDY

Existing knowledge of the processes of growth, development, function, adaptation, and learning in the human organism is yet too limited to bring any discussion of even one of these processes to a closely knit, well-defined conclusion. What we know about these processes exists largely as isolated organizations of authenticated specialized data, connected together for the practice of our various fields by large amounts of interpolated or extrapolated specialization so as to give us some semblance of a working whole.

For these reasons this concluding chapter of the first part of our discussions on "Vision, Growth, and Development" is not presented as a fully organized paper. It is presented, rather, as a tentative "Outline for Further Study" so that the reader can expand or modify it by his own thinking or by any additional data that may come into his possession.

Human Beings As Organisms

§1.1. The human being is a living thing, a mammalian organism, sharing the essential characteristics of all organisms.

¶1.1.1, The human organism, like all organisms, is dynamic; that is, it goes into action for certain purposes as a result of inner physiologic processes.

1.1.1.1. Characteristic of all organisms are the processes of assimilating materials from the environment, transforming the energy of these materials, and using this energy for growth, reproduction, and establishing balances with the various forces and restraints in both its internal and external environments, (the basic protoplasmic functions of irritability, metabolism, and reproduction).

§1.1.2. All human beings move through the same general pattern of sequential structuring in the growth process.

1.1.2.1. Within determinable limits, every individual has his own unique configuration of this general pattern in terms of rate, timing, and synchrony of growth of parts.

1.1.2.2. The whole process is mediated by inner biochemical controls, but quality of the structures produced is markedly influenced by environmental forces.

§1.1.3. As the individual progresses through the patterns of growth, he finds himself possessed of new physical resources determining his generalized behaviors in relation to the forces and restraints in his surround, and he is confronted by new demands from his culture and from his environment which expand as a result of his new behaviors.

1.1.3.1. The human organism and its generalized behaviors are shaped or specifically developed by the processes of interacting with the physical and cultural surroundings in which the individual grows up.

1.1.3.2. "Development...is the adaptations that the organism makes to specific requirements of its environment while growth is taking place. In these adaptations the generalized systemic forms laid down by the innate patterns of growth are modified, or converted into specific forms and patterns determined by environmental requirements." (Paper Two*)

Organic Function and Adaptation

§2.1. The function of dynamic energy systems (living organisms) is to promote their own integrity--to survive.

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*.- "Paper Two", etc., refers to papers in the Series, "Vision, Growth, and Development".

¶2.1.1. Organic integrity and survival are promoted in higher organisms, such as man, through specialized parts and systems, through a complex interconnecting system permitting various organizations of parts and systems, and through modification of structure.

2.1.1.1. "Survival is promoted by living forms through adjusting internal and external forces to hold those forces in dynamic equilibrium, and through modifying their structures from time to time, within the limits of internal equilibria, to better resist or reduce stresses produced in them by specific environments." (Paper One)

¶2.1.2. Specialization of parts or systems within the whole organism is solely to make more efficient the three primary protoplasmic behaviors which promote the organism's integrity and survival.

2.1.2.1. Specialized parts do not function independently. They function within the functioning of the whole. Their functioning, while definable in part, is inseparable from the functioning of the system of which they are a unit and from the functioning of the total organism.

¶2.1.3. Modification of structure through function is the major portion of the processes of adjustment or adaptation of higher organisms and their potential, generalized behaviors to the requirements of specific environments.

2.1.3.1. "Superiority of organic form is apparently the product of...capacity for modification of various structures, as a result of function, within the limits of internal equilibria, so as to make function in relation to specific environments increasingly efficient." (Paper One)

2.1.3.1.1. The full discriminatory power of the various sense organs, the development of the full potentialities of muscle, the efficient contours of supporting structures, all result from use or function in a wide variety of specific and appropriate tasks.

2.1.3.2. "The child's body or bodily systems grows along the lines of stress induced in it by various activities, in order to reduce those stresses." (Paper Three)

2.1.3.3. Modifiability of structure through function, in effect, records the results of the uses made by the organism of its structures in various combinations and actions, and the effect on the organism's total economy of these uses in various specific situations.

2.1.3.3.1. "The extent of man's nervous system and his capacity for modification of structure through function gives man the capacity to 'learn'." (Paper One)

2.1.4. Organic adaptation and modification of structure through function (with resulting alteration of function) is to the immediate surround, and it tends to be promiscuous from the social point of view.

2.1.4.1. The purpose of organic function is to satisfy immediate organic need determined by one or more of the basic protoplasmic behaviors.

2.1.4.2. Unusual or excessive demands on function by the immediate surround can so alter structure that resulting altered function can be inappropriate or inefficient in subsequent situations.

2.1.4.2.1. "If the forces impinging on the organism are too great for the organism's capacities; or, if the organism is restrained from acting toward them; or, if the environmental forces are distributed in patterns inconsistent with the organism's basic patterns of behavior for responding to such forces; or, if the organism is not in proper condition to meet ordinary forces...the organism is harmed." (Paper Three)

2.1.4.3. Meaning follows function in the human organism, and that meaning directs subsequent behavior in a social direction only when function has satisfied organic need in socially acceptable behavior.

2.1.4.3.1. The direction of meaning toward social ends requires group control of total situations so the function aroused by all the forces in the total situation can be directed into socially desirable behaviors which satisfy all the organic needs to which those functions are related.

2.1.4.4. Unless the forces in the physical surround, the cultural demand of the learning situation, and organic function can all be reconciled so that the child has freedom to perform his social tasks of development in a manner that will satisfy the biologic needs those tasks and their surroundings arouse, unbalanced modification of structures and of development can be produced, leading to later operational conflicts, distortions of sensation and performance, socially inefficient behaviors, or actual bodily breakdown.

Educational Implications

§3.1. Children learn through activity.

§3.1.1. This is the basic concept in all modern curricula.

§3.1.2. Today's educational programs largely interpret this concept through reading, writing, drawing, construction activities, or the performance of other tasks involving close visually-centered activities.

§3.2. All activity, implicit or overt, educationally purposeful or extraneous, from the organism's point of view is adaptive or learning activity.

§3.2.1. What the child will eventually be is the product of all the situations or forces which have set him into action, and thereby molded or limited his growth and development and the use he can make of his resources.

§3.3. The child is set into action not only by the purposeful stimuli of curriculum but also by all the social and physical forces and restraints existing in the classroom.

§3.3.1. The distribution of light, as well as the task illuminated; the control of sound, in addition to the thing said; the design or form of equipment for efficient and constructive body mechanics, as well as provision of support for a task; all enter into initiating the total actions of the child in school.

§3.3.2. Physical factors and forces can be either constructive or adverse in promoting growth and development.

§3.4. The child adapts physically in a manner much similar to his method of psychological adjustment: "The child grows along a line of stress to reduce the stress."

§3.4.1. Innate growth patterns provide for development of a bilaterally balanced organism functioning around definable centers of reference.

3.4.1.1. Principal centers of reference are the lines of intersection of the medial and lateral planes of the head and trunk, and the lines of intersection of certain horizontal planes with these medial and lateral planes. (1)

§3.4.2. Static and stato-kinetic reflexes, functioning in relation to these centers of reference, provide balancing mechanisms for organisms against various environmental forces, and against the forces and movements represented in the action patterns of any task. (2)

§3.4.3. Visually elicited reflexes, both innate and conditioned, dominate or inhibit all other balancing mechanisms. (3)

§3.4.4. Visually induced gradients of activity when not controlled to meet needs of organisms, can be restraining and handicapping, resulting in limitations of learning, dissipation of energies, or even in warping of growth, development and well-being. (1)

§3.5. Successful learning through sustained close visually-centered activities is attained in action patterns at limits safely within, but constantly approaching, the maximum tolerances of the child for the bodily stresses these activities induce.

§3.5.1. Even a limited amount of additional stimulation from poorly controlled physical factors or forces, continuing through a significant time carries the child beyond his tolerances for body or systemic stresses and leads to handicapping and warping strains.

Vision and Seeing

§4.1. "Seeing", organically, is the detection of differences in the way light is distributed over the various parts of the environmental field encompassed by the eyes.

§4.1.1. Seeing is essentially the organic function of brightness differences and brightness contrasts. (4)

§4.1.2. It is the sensory portion of a total behavior pattern or patterns related to or elicited by differences in light distribution.

§4.1.3. From the view point of educational planning seeing is only of significance in terms of:

4.1.3.1. The minimum and optimum brightness differences and contrast values which are necessary, at various developmental levels of the child, for the detection of light distribution patterns that are culturally and personally meaningful.

4.1.3.2. The minimum quantities and the qualities of light which are needed to maintain, economically, those meaningful patterns of brightness differences and contrasts; and,

4.1.3.3. The pathologies and functional deviations which might exist in individual children that would interfere with the educationally adequate detection of those meaningful patterns, together with the earliest possible detection of such children, the direction of them toward satisfactory correction of their difficulties, and the adjustment of brightness differences and contrasts to meet the needs of those children with difficulties that have not been or can not be corrected.

§4.2. "Vision", from the view point of learning, is the adjustive or adaptive actions aroused by a pattern of light distribution. It is the total behavior of the organism elicited by a pattern of brightness differences or contrasts.

§4.2.1. "The child does not see to see, he sees to act." (Paper Three)

§4.2.2. The meanings attributed to certain light distribution patterns, such as the brightness differences or contrasts between the type printed on a page and the background of the paper making that page, or the visible outlines and contours of an object or form, are not innate with the organism but are defined by society and must be learned by the organism through educational direction of its experiences in adjusting or adapting to light distribution patterns.

§4.2.3. The physiologic functions of light and its patterning into brightness differences and contrasts by the organism's surround can be summarized much in the following order: (5)

4.2.3.1. Promoting the organization of the body's readiness to adjust or perform in terms of the brightness contrasts or objects in the total visual field which are related to the body's economy;

4.2.3.2. Aiding in the spatial orientation of the body and its balance with the immediate forces in its environment;

4.2.3.3. Initiating reflex adjustments of the eyes, head, and total posture of the body so as to promote efficient resolution and efficient reaction toward contrasts or objects in the visual field related to the organism's economy;

4.2.3.4. Directing final and efficient resolution of the visual image; and

4.2.3.5. Incitation of the visually determined responses the body's economy requires toward the image resolved and perceived.

§4.3. Both vision and seeing are tridimensional functions and their dimensional nature must be taken into account in educational planning for visually-centered activities.

§4.3.1. Because the organism reacts as a unit in performing these three dimensional functions, classroom planning must coordinate all the factors affecting and effecting optimum freedom of performing purposeful visually-centered tasks into a unitary three dimensional surround (i.e., the coordinated planning of light sources both natural and artificial, decoration, the optical aspects of educational materials, seating and other equipments, etc., so as to meet the total developmental needs of the child in his visually-centered experiences in a three dimensional world).

4.3.1.1. Vision, for example, not being merely acuity and identification, cannot have as its lighting requirements the maximum quantity of light to promote maximum resolution of details restricted to a plane surface. Such a situation would "freeze" the child into a single system action pattern to the detriment of his other bodily systems, and to his total detriment in gaining maximum learning values from the total situation. Lighting should be planned in terms of the minimum quantities of light which will give those qualities of distribution needed for efficient all over functioning in relation to the specific educational tasks to be performed.

4.3.1.2. Lighting planning is not a problem of bringing the outdoors indoors unless the task indoors is similar to the one outdoors--it is a problem of fitting qualities of light and light distribution patterns to the adaptive mechanisms of the eye and body so as to promote effectively and efficiently the indoor tasks. (5)

§4.4. The visually-centered skills required in socially defined visually-centered tasks are learned skills derived from the generalized basic behavior patterns aroused by the organism's efforts to meet its needs in adjusting or adapting to various distributions of brightness differences or contrasts.

§4.4.1. Because all contrasts within a certain degree arouse action, then the action arousing contrasts in a classroom must be confined to the purposeful forms or objects of the visually-centered tasks of the curriculum.

¶4.4.2. In all other areas of the visual field the contrasts or brightness differences between brightest and darkest areas must be reduced to a minimum just sufficient to define his surround as a three dimensional unit of space. The child's freedom to perform any given task depends upon how well the brightnesses throughout the classroom, providing a background for that task, approach an even distribution, or unity with the immediate background of the task itself, yet define the task as part of a three dimensional whole.

¶4.4.3. The equipment furnished for performing or supporting the visually-centered task must be in keeping with the total behavior patterns aroused by that task so that the performances will not be restrained or altered and so that dynamic equilibria may be attained.

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